

**FINAL**

**Risk-Based Characterization of  
Site ST-08 (Building 41105)**



**Pope Air Force Base  
North Carolina**

**Prepared For**

**Air Force Center for Environmental Excellence  
Technology Transfer Division  
Brooks Air Force Base, Texas**

**and**

**4 CES/CEV  
Pope Air Force Base  
North Carolina**

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**RISK-BASED CHARACTERIZATION OF  
SITE ST-08 (BUILDING 41105)  
POPE AIR FORCE BASE, NORTH CAROLINA**

**AETC Contract No. F41689-96-D-0710  
Order No. 5015**

**Prepared for  
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE  
TECHNOLOGY TRANSFER DIVISION  
BROOKS AIR FORCE BASE, TEXAS**

**and**

**4 CES/CEV  
POPE AIR FORCE BASE, NORTH CAROLINA**

**September 1999**

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## ACRONYMS AND ABBREVIATIONS

$\mu\text{g/L}$	micrograms per liter
AETC	Air Education and Training Command
AFB	Air Force Base
AFCEE/ERT	Air Force Center for Environmental Excellence, Technology Transfer Division
ASTM	American Society for Testing and Materials
BC	biodegradation capacity
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
$^{\circ}\text{C}$	degrees centigrade
CAP	Corrective Action Plan
$\text{CH}_4$	methane
$\text{CO}_2$	carbon dioxide
COPC	chemical of potential concern
CPT	cone penetrometer technology
CSA	comprehensive site assessment
CSM	conceptual site model
CT	central tendency
DEHNR	Department of Environment, Health, and Natural Resources
dh/dl	hydraulic gradient
DO	dissolved oxygen
EDB	ethylene dibromide
EPH	extractable petroleum hydrocarbons
ES	Engineering-Science, Inc
$\text{Fe}^{2+}$	ferrous iron
$\text{Fe}^{3+}$	ferric iron
$f_{oc}$	fraction organic carbon
ft/day	feet per day
ft/ft	foot per foot
ft/yr	feet per year
GC	gas chromatograph
GCLs	gross contaminant levels
HASP	health and safety plan
HDPE	high-density polyethylene
K	hydraulic conductivity
$K_{oc}$	organic carbon partition coefficient
kg/L	kilograms per liter
L/kg	liters per kilogram
LIF	laser-induced fluorescence
LLNL	Lawrence Livermore National Laboratories
LNAPL	light, non-aqueous phase liquid

mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ml	milliliter
msl	mean sea level
MP	monitoring point
mV	millivolt
MW	monitoring well
N	nitrogen
NCDEHNR	North Carolina Department of Environment, Health, and Natural Resources
$n_e$	effective porosity
NCAC	North Carolina Administrative Code
$n_t$	Total porosity
O <sub>2</sub>	oxygen
ORP	oxidation/reduction potential
oz	ounce
PAH	polynuclear aromatic hydrocarbon
Parsons ES	Parsons Engineering Science, Inc.
$\rho_b$	Soil Bulk Density
PID	photoionization detector
ppmv	parts per million, volume per volume
R	retardation coefficient
RME	reasonable maximum exposure
RNA	remediation by natural attenuation
SAP	sampling and analysis plan
SAR	soil assessment report
SCAPs	site characterization and analysis penetrometer system
SSTLs	site-specific target levels
SU	standard unit
SVE	soil vapor extraction
TCLs	target cleanup levels
TOC	total organic carbon
TRPH	total recoverable petroleum hydrocarbons
TVH	total volatile hydrocarbons
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VMP	vapor monitoring point
VOCs	volatile organic compounds
VPH	volatile petroleum hydrocarbons
V <sub>s</sub>	seepage velocity
VW	vent well

## SECTION 1

### INTRODUCTION

Parsons Engineering Science, Inc. (Parsons ES) was retained by the Air Force Center for Environmental Excellence, Technology Transfer Division (AFCEE/ERT) under Air Education and Training Command (AETC) Contract No. F41689-96-D-0710, Order No. 5015 to evaluate the occurrence of natural contaminant attenuation and the risks posed to potential human and ecological receptors by site contamination at Site ST-08 (Building 41105), Pope Air Force Base (AFB), North Carolina.

#### 1.1 DESCRIPTION OF THE RISK-BASED APPROACH

The objective of risk-based remediation is to reduce the risk of specific chemicals to human health and/or ecological receptors such as animals or plant life. For any chemical to pose a risk, four elements must exist at the site:

- A source of chemical contamination that exceeds or could generate chemical contamination above health-protective or aesthetic standards;
- A mechanism of contaminant release;
- A human or ecological receptor available for chemical contact; and
- A completed pathway through which that receptor will contact the chemical.

If any one of these four elements is absent at a site, there is no current risk. The reduction or elimination of risk can be accomplished by limiting or removing any one of these four elements from the site.

The goal of this risk-based remediation approach is to assist the Base and its primary environmental contractors in finding the most cost-effective method of reducing present and future risk by combining three risk reduction techniques:

- Chemical Source Reduction - Achieved by natural attenuation processes over time or by engineered removals such as free product recovery, soil vapor extraction (SVE), or *in situ* bioventing.
- Chemical Migration Control - Examples include natural attenuation of a groundwater plume, and SVE to prevent migration of hazardous vapors to a receptor exposure point.

- Receptor Restriction - Examples include land use controls and site fencing to eliminate chemical exposure until natural attenuation and/or engineered remediation reduce the chemical source and/or eliminate the potential for chemical migration to an exposure point.

## **1.2 RISK-BASED APPROACH TASKS**

The major tasks of this risk-based project are:

- Assessing available data and collecting any supplemental site characterization data necessary to define the nature, magnitude, and extent of soil, soil gas, surface water and groundwater contamination and to document to what degree natural attenuation processes are operating at the site; and
- Determining whether an unacceptable risk to human health or the environment currently exists or may exist in the foreseeable future using reasonable exposure scenarios, quantitative contaminant fate and transport models, and exposure concentration estimates.

All work was performed in accordance with guidance and requirements contained in the project Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP) (Parsons ES, 1997a and 1997b).

## **1.3 REGULATORY REQUIREMENTS**

This section describes the North Carolina Department of Environment, Health, and Natural Resource (DEHNR) approach for risk-based remedial action at sites contaminated with petroleum products. The Groundwater Section Guidelines for the Investigation and Remediation of Soil and Groundwater, Volume II, Petroleum Underground Storage Tanks (USTs) (North Carolina DEHNR, 1998a) and the North Carolina Administrative Code (NCAC), Title 15A, Department of Environmental and Natural Resources, Division of Water Quality, Subchapter 2L, Classifications and Water Quality Standards and Risk-Based Assessment and Corrective Action for Petroleum USTs (15A NCAC 2L) present guidance for determination of soil and groundwater remedial requirements for closure of petroleum-contaminated UST-related sites.

The Proposed Risk-Based Assessment and Corrective Action Rules for Petroleum Underground Storage Tanks (North Carolina DEHNR, 1998b) describes which sites are covered by the rule. Existing discharges or releases can be covered by the rule if site assessment has not been completed, or if application of the rule will be more cost effective, or more protective of human health or the environment. Because recent field sampling and data evaluation has been performed for Site ST-08 to facilitate evaluation of risks posed by site contamination, it is assumed that the new risk-based rules are applicable for this site.

### **1.3.1 Risk Classification**

This subsection details the North Carolina DEHNR's (1998b) classification process that determines the risks posed by a discharge or release. If the criteria for more than



one risk category apply, the discharge or release will be classified as the highest applicable risk classification.

#### High Risk

- Water supply well contaminated,
- Water supply well threatened,
- Groundwater has potential future use as water supply,
- Explosion or fire hazard present, or
- Release poses imminent danger to human health or the environment.

#### Intermediate Risk

- Surface water threatened,
- Deeper aquifer that is or may be used as a drinking water supply is threatened,
- Wellhead protection area affected, or
- Gross levels of contamination are present.

#### Low Risk

- Not classified as high or intermediate risk, or
- Based on site-specific information, the North Carolina DEHNR determines that the discharge or release poses no significant risk to human health or the environment.

If free product is present, the risk level of the site is automatically classified as being at least intermediate. Based on available information, Site ST-08 should be classified as an intermediate risk site.

### 1.3.2 Groundwater Assessment and Cleanup

Groundwater compliance requirements associated with UST releases must comply with the cleanup levels established for the appropriate risk category. The following summarizes the guidance for discharges or releases reported on or after January 2, 1998 for each of the three risk categories (North Carolina DEHNR, 1998a). As described in Section 1.2, preexisting discharges or releases also may follow this guidance if site assessment has not been completed or if application of the risk-based rules will be more cost effective or more protective of human health or the environment.

For a high-risk discharge or release, the responsible party must perform a comprehensive site assessment (CSA) and submit a report documenting the results. If the North Carolina DEHNR cannot reclassify the discharge or release as low risk following the receipt of the CSA report, a corrective action plan (CAP) must be

submitted. A CAP must propose appropriate remediation strategies to restore groundwater quality to the level of the standards established in 15A NCAC 2L .0202. In any CAP, natural attenuation must be considered as a remedial option and used to the maximum extent possible. Prior to site closure, the responsible party must submit a Site Closure Report, demonstrating that contamination has been remediated to the applicable cleanup levels.

The process for intermediate risk discharges or releases is the same as described above for high risk sites; however, the CAP must propose to remediate contaminated groundwater to a level sufficient to protect surface water, wellhead protection areas, and deeper Coastal Plain aquifers that are or could be used as a source for drinking water. At a minimum, contaminated groundwater must be remediated to the gross contaminant levels (GCLs) established in 15A NCAC 2L .0115(d)(2)(D).

For a low risk discharge or release, the North Carolina DEHNR will notify the responsible party pursuant to 15A NCAC 2L .0115(h) that no further action is required. However, prior to issuing this notification, the responsible party must demonstrate that soil contamination has been cleaned up to the lowest applicable levels. No further groundwater assessment or cleanup is required.

### **1.3.3 Soil Assessment and Cleanup**

Soil cleanup requirements associated with UST releases must comply with the cleanup levels established for the appropriate risk category. The following summarizes the guidance for discharges or releases reported on or after January 2, 1998, for each of the three risk categories (North Carolina DEHNR, 1998a).

For high and intermediate risk releases, the responsible party must document the vertical and horizontal extent of soil contamination. The soil assessment information should be incorporated into a CSA report, and the report also should include a proposal for remediating soil contamination. Prior to site closure, the responsible party must demonstrate that soil contamination has been cleaned up to applicable cleanup levels. This information should be included in a site closure report. Soil contamination at high or intermediate risk sites must be remediated to the lowest of:

1. Residential or Industrial/Commercial maximum soil contaminant concentrations, whichever is applicable; or
2. Soil-to-groundwater maximum soil contaminant concentrations.

If the risk classification of a discharge or release is downgraded to low following the submittal of the CSA report, a soil cleanup plan must be submitted to address remediation of soil contamination, rather than a comprehensive CAP.

For low risk releases, a responsible party must submit a Soil Assessment Report (SAR), documenting the vertical and horizontal extent of soil contamination. Soil contamination must be remediated to the residential or industrial/commercial maximum contaminant concentrations, whichever is applicable. The plan for remediating soil contamination should be incorporated into the SAR. Prior to closure, a responsible

party must submit a soil cleanup report with a site closure request documenting that soil has been remediated to applicable cleanup levels and requesting that the North Carolina DEHNR issue a notice of no further action.

## **1.4 REPORT ORGANIZATION**

This CAP consists of 8 sections, including this introduction, and 6 appendices. Site background, including operating history and a review of environmental site investigations conducted to date, is provided in the remainder of this section. Section 2 summarizes the 1998 site characterization activities performed by Parsons ES. Physical characteristics of the site and surrounding area are described in Section 3. A Tier 1 evaluation is completed in Section 4 to identify those site contaminants that are considered chemicals of potential concern (COPCs). Section 5 summarizes the nature and extent of COPC contamination at the site. Section 6 addresses the effects of natural chemical attenuation processes that are documented to be occurring at the site, and presents chemical fate and transport and receptor exposure analyses. Section 7 presents the Tier 2 risk evaluation along with the summary and conclusions of this risk-based evaluation. Section 8 presents references used in preparing this document.

Analytical data sheets and chain-of-custody records are in Appendix A. Pertinent information from prior investigations is presented in Appendix B. Boring logs, groundwater sampling forms, and well construction diagrams for all drilling and sampling activities completed by Parsons ES during the December 1998 field effort are included in Appendix C. Appendix D includes the supporting documentation for the quantitative calculations used in the predictive chemical fate assessment and computation of Tier 2 site-specific target levels (SSTLs). Appendix E includes BIOSCREEN model input. Appendix F contains the data quality assessment report.

## **1.5 SITE DESCRIPTION AND BACKGROUND**

Pope AFB is located on 1,869 acres within the Fort Bragg Military Reservation, northwest of Fayetteville, North Carolina in the south-central part of the state. Site ST-08 (Building 41105) was formerly used as a fuel oil storage and distribution facility, and housed four 25,000-gallon USTs. The site is located near the center of the Base, between Taxiway B and Boxcar Street and adjacent to Tank Creek. Several other petroleum tank sites around the Base also are included in Site ST-08. In this document, any references to "Site ST-08" are intended to refer exclusively to the former fuel oil storage facility located between Taxiway B and Boxcar Street. Figure 1.1 shows the location of Site ST-08 at Pope AFB.

This site was previously a number 2 fuel oil (heating oil) storage and distribution facility for the Base. Presently, there are no buildings or structures in the vicinity of Site ST-08. Fuel oil was delivered to the site in tanker trucks and by rail cars, where it was unloaded and stored in four 25,000-gallon steel USTs. Fuel delivery trucks were then used to distribute the fuel oil to smaller fuel storage tanks at buildings throughout the Base, where it was used for heating purposes. The Base reports that the four USTs were installed in the early- to mid-1970s.

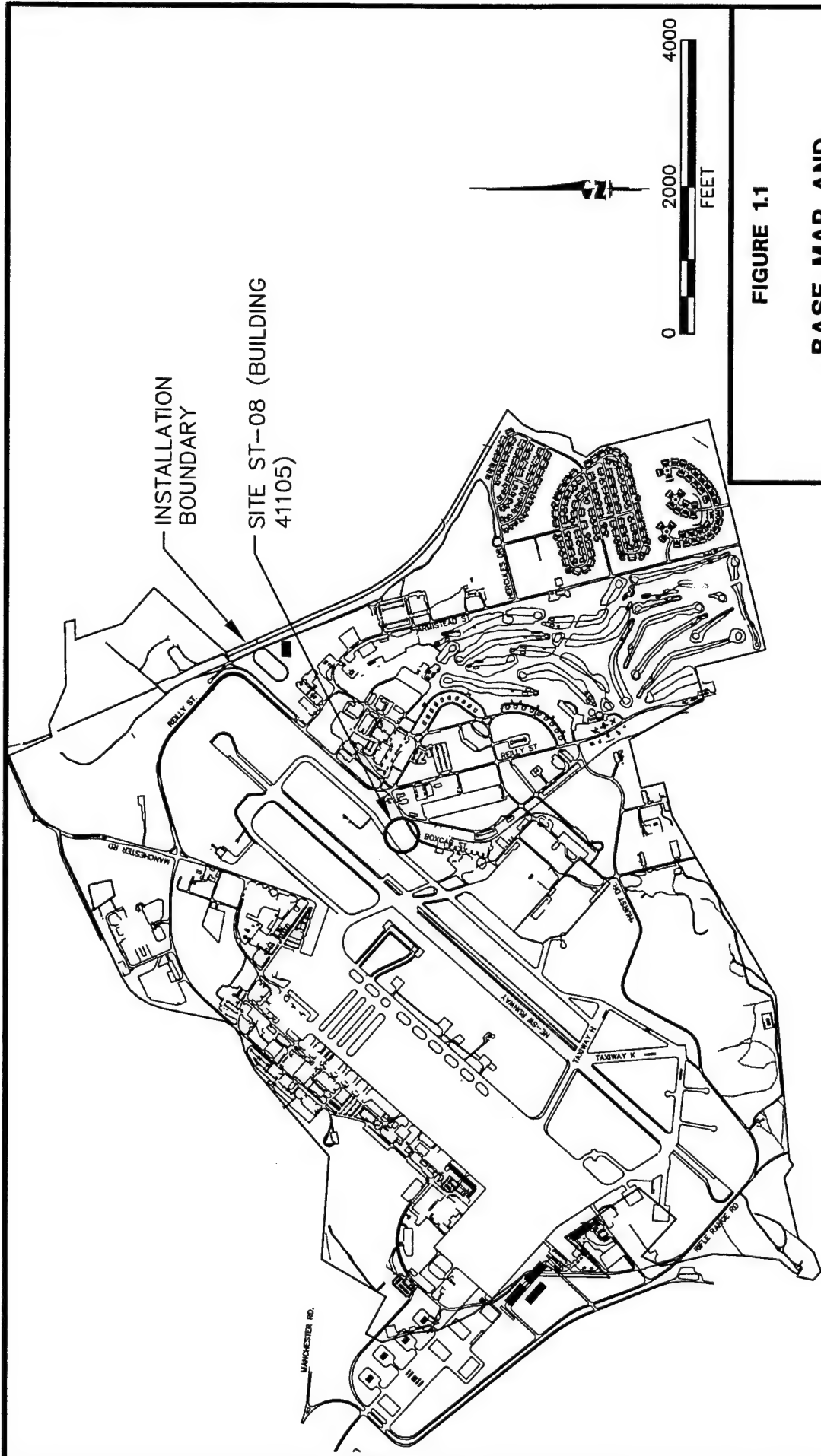


FIGURE 1.1

## BASE MAP AND SITE LOCATION

Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

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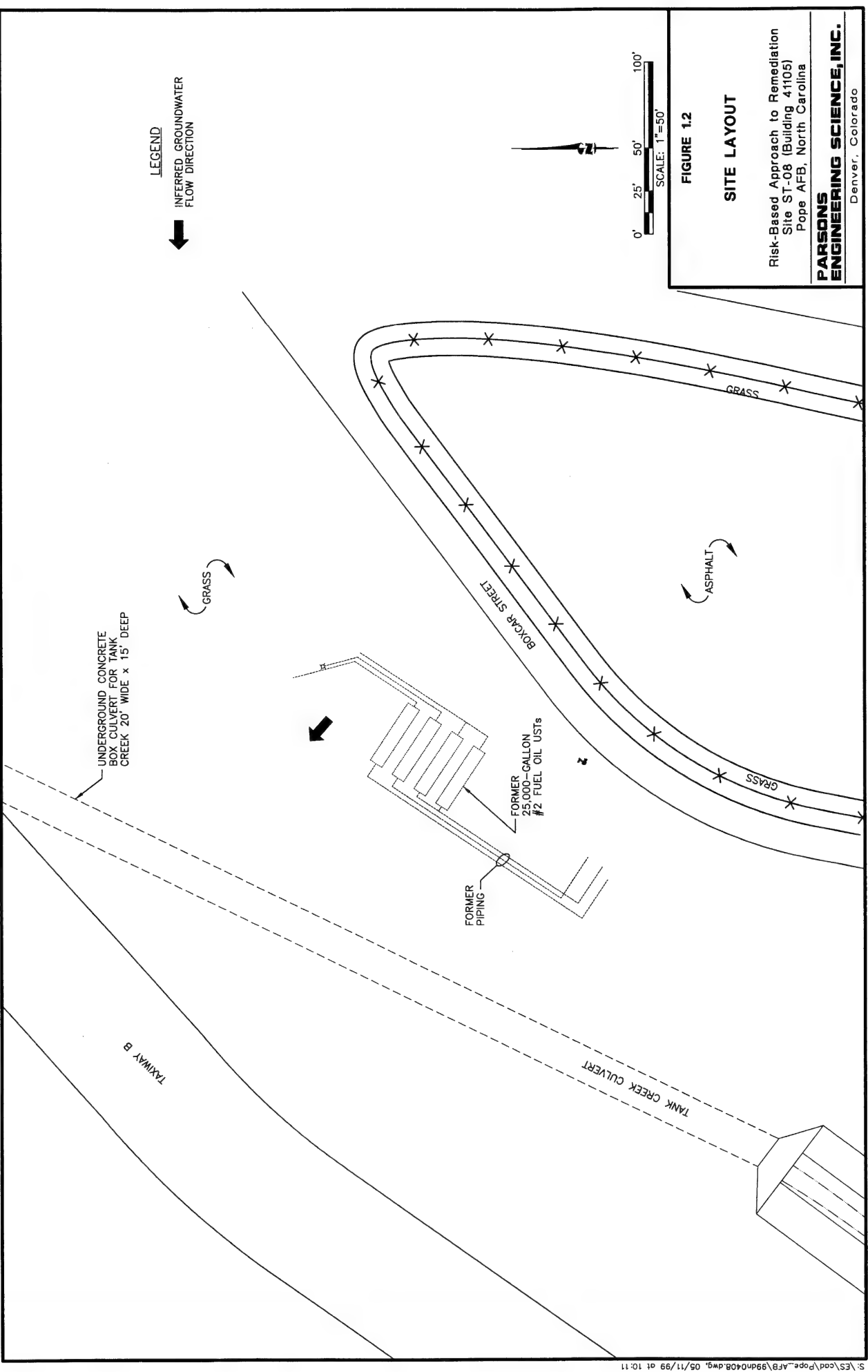
Denver, Colorado

The four USTs, ancillary piping, and fuel dispensers were excavated and removed from the site in November 1992, after the UST system failed integrity testing. Contaminated soil was encountered during the UST system removal, and fuel (free product) was observed floating on water that collected in the open excavation. Fuel-contaminated soil excavated during the UST system removal was placed back into the excavation after the USTs were removed. The UST removal contractor reportedly placed a layer of thick plastic in the excavation at a depth of about 15 feet below ground surface (bgs) prior to backfilling. Figure 1.2 shows the site layout with the former UST system location.

The US Army Corps of Engineers (USACE) performed a soil gas survey at the site in May 1994 to estimate the extent of the fuel contamination and to investigate the suspected presence of oily-phase product (Parsons ES, 1995). The soil gas investigation was conducted primarily northwest, north, and northeast of the former USTs because it was suspected that fuel contamination was migrating toward Tank Creek. Fifty shallow temporary soil gas probes were installed to depths just above the water table, and soil gas samples were collected and analyzed with a portable field gas chromatograph (GC). The soil gas samples were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), and the hydrocarbons n-pentane, n-hexane, n-heptane, e-octane, n-nonane, and n-decane (Parsons ES, 1995). Approximately 17 of the 50 samples had detections of one or more of these compounds; however, the total BTEX concentrations were generally less than 10 parts per million by volume (ppmv) for most of the samples. Low concentrations of BTEX and other volatile organic compounds (VOCs) are typical for heavier fuels such as number 2 fuel oil.

In August 1994, Parsons ES (1995) (formerly Engineering-Science, Inc., [ES]) conducted a preliminary soil gas/soil boring survey at the Site ST-08 Former Fuel Oil Storage Facility as part of a Base-wide search for candidate bioventing study sites (Figure 1.3). During this limited soil gas survey, Parsons ES utilized a soil gas probe with a retractable tip. Four temporary soil gas probes were installed within the former UST excavation area to monitor total volatile hydrocarbons (TVH), oxygen (O<sub>2</sub>), and carbon dioxide (CO<sub>2</sub>) concentrations within the soil gas. TVH concentrations ranged from 980 ppmv to greater than 10,000 ppmv at depths ranging from 2 to 8 feet bgs. Depleted O<sub>2</sub> and increased CO<sub>2</sub> levels within contaminated soil gas are an indication of aerobic fuel biodegradation in the soils. Oxygen concentrations ranged from 11 to 16 percent in shallow soils (<5 feet bgs). Soil gas O<sub>2</sub> concentrations in deeper soils (5 to 8 feet bgs) ranged from 0 to 2.5 percent. CO<sub>2</sub> concentrations ranged from 5.5 to 12.5 percent, and were generally higher in the deeper, more contaminated soils.

In January 1995, the AFCEE (1995) performed a preliminary site screening at Site ST-08 as part of a national research and development program to identify candidate sites for future innovative technology programs. This screening involved the use of a modified cone penetrometer technology (CPT) rig, also known as the site characterization and analysis penetrometer system (SCAPS), owned and operated by the USACE Kansas City District. The SCAPS rig is equipped with a fiber-optics laser system that uses laser-induced fluorescence (LIF) to detect oily-phase petroleum contaminants in soils and groundwater. Results of the CPT/LIF study were not available.



**LEGEND**  
 INFERRED GROUNDWATER  
 FLOW DIRECTION



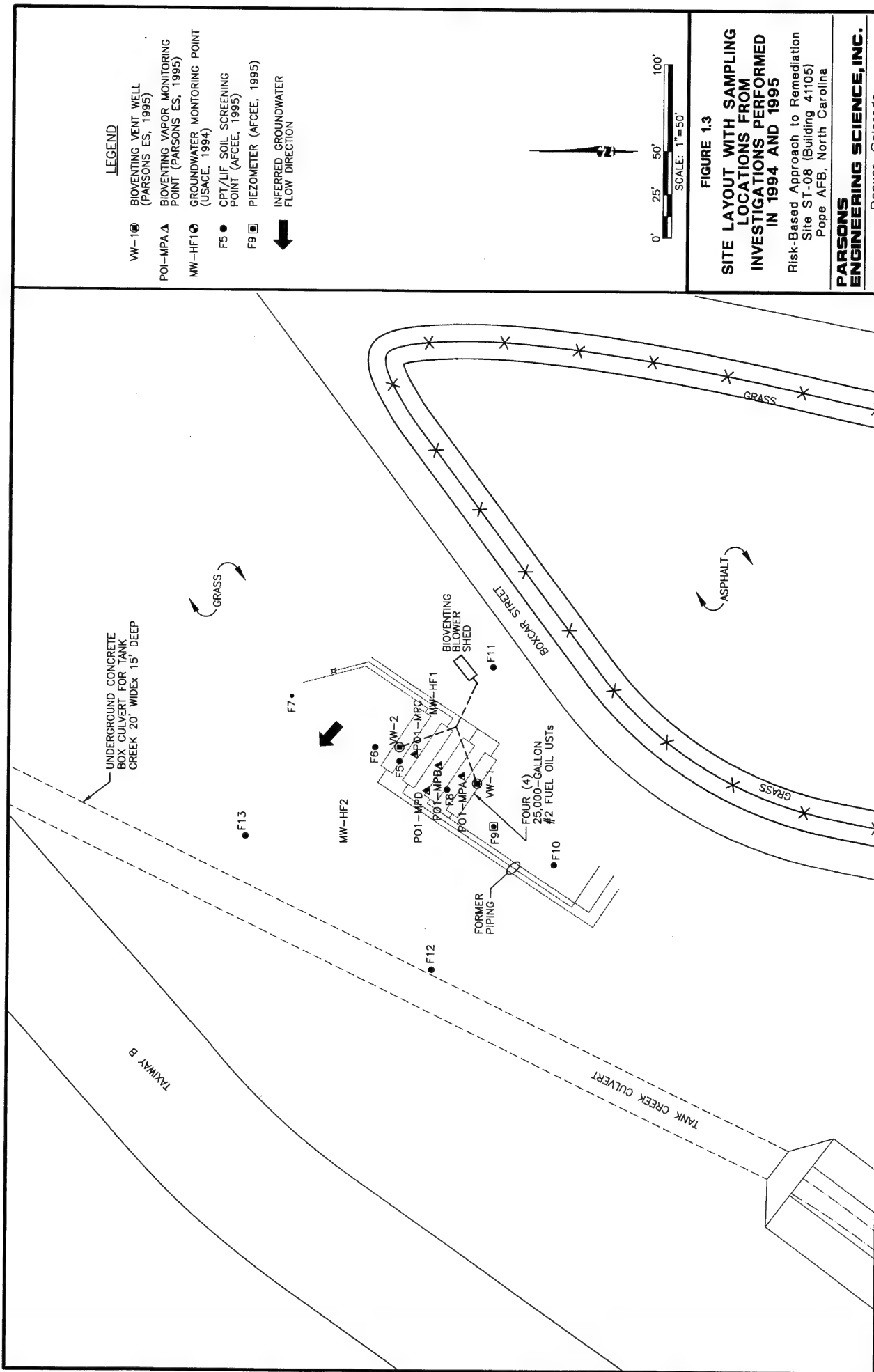
0' 25' 50' 100'  
 SCALE: 1"=50'

**FIGURE 1.2**

**SITE LAYOUT**

Risk-Based Approach to Remediation  
 Site ST-08 (Building 41105)  
 Pope AFB, North Carolina

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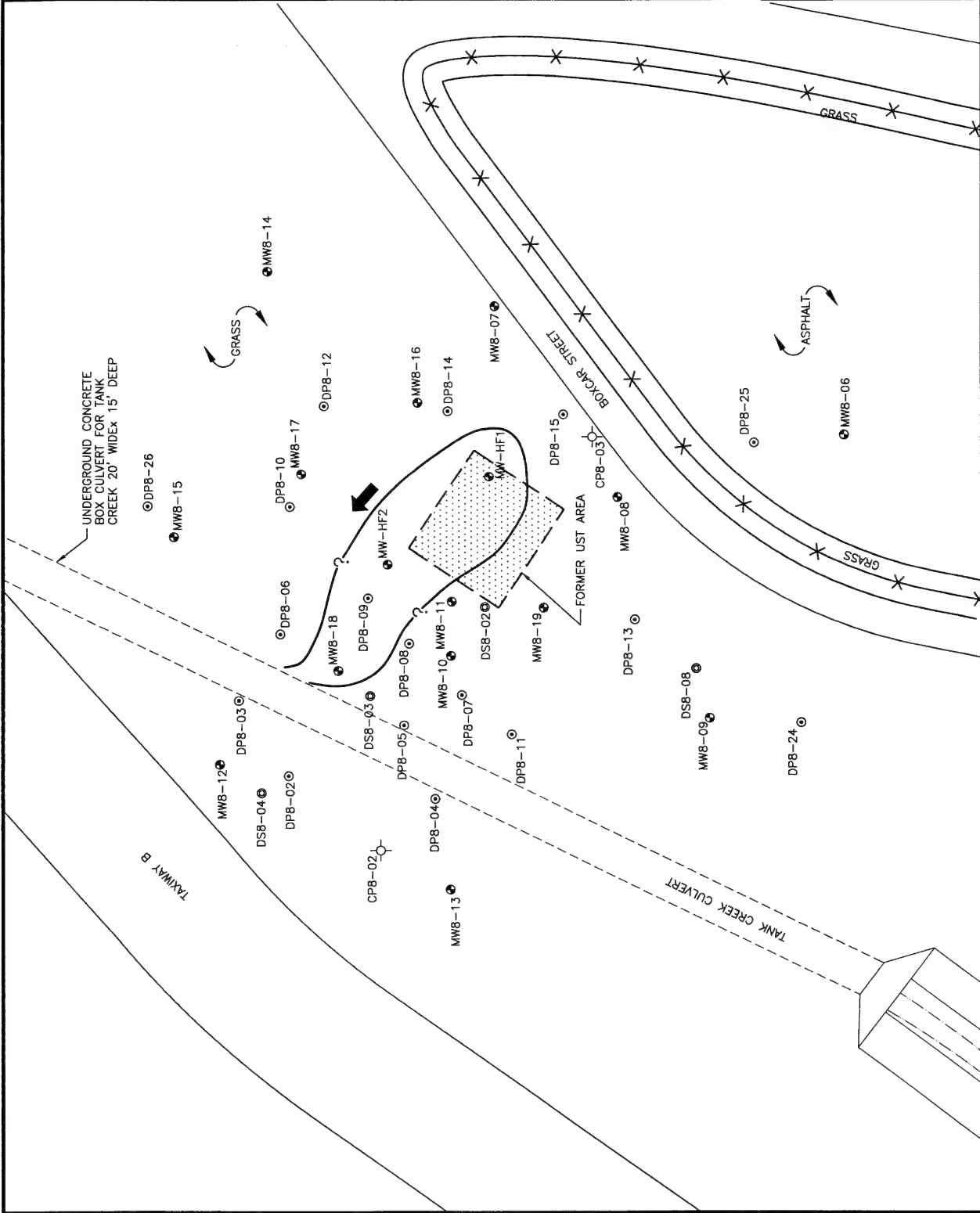


**FIGURE 1.3**  
**SITE LAYOUT WITH SAMPLING LOCATIONS FROM INVESTIGATIONS PERFORMED IN 1994 AND 1995**  
Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina  
**PARSONS ENGINEERING SCIENCE, INC.**  
Denver, Colorado

In February 1995, Parsons ES installed two air injection vent wells (VWs), four permanent vapor/pressure monitoring points (VMPs), and an air injection piping system for interim testing and long-term use during the bioventing study. Figure 1.3 shows the VW and VMP locations relative to other site features. Currently, the bioventing system is still in operation.

From January 1996 to February 1997, a CSA was performed at Site ST-08 by URS Greiner, Inc. (1998). CSA sampling locations are shown on Figure 1.4. The CSA included soil and groundwater sampling, groundwater monitoring well installation, hydraulic conductivity testing, and geotechnical sampling. Selected results from the CSA are contained in Appendix B.





## SECTION 2

### SITE CHARACTERIZATION ACTIVITIES

Several soil and groundwater investigations have been conducted at Site ST-08. These investigations focused on characterizing and delineating dissolved hydrocarbons in groundwater and residual fuel hydrocarbons in soil. Parsons ES conducted a supplemental investigation at the site during December 1998 to collect site-specific data relevant to quantifying the effects of natural contaminant attenuation processes. Soil, surface water, and groundwater were sampled to:

- Further delineate the extent of contamination;
- Assess temporal trends in soil and groundwater contaminant concentrations;
- Support contaminant fate and transport analyses; and
- Develop appropriate exposure-point concentrations to compare to final remediation goals.

Data collected during previous investigations were used to augment this study. Emphasis was placed on collecting data documenting the natural biodegradation and attenuation of fuel hydrocarbons in soil and groundwater at the site. The December 1998 supplemental site characterization activities performed by Parsons ES are briefly described in the remainder of this section. Most site characterization procedures (i.e., soil, soil gas, and groundwater sampling procedures) are described in detail in the project SAP (Parsons ES, 1997a).

#### 2.1 SCOPE OF DATA COLLECTION ACTIVITIES

Field data collection efforts focused on investigating specific chemical constituents that potentially pose a threat to human health or the environment. The chemicals targeted for study at this site were specified in North Carolina DEHNR (1998a).

The risk-based investigation for the site was conducted according to the methodologies presented in the *Work Plan for the Risk-Based Investigation of Site ST-08 (Building 41105)* (Parsons ES, 1998), hereafter referred to as the work plan. The work plan was developed according to available guidelines and requirements of the North Carolina DEHNR to support site closure.

The following sampling and testing activities were performed by Parsons ES during December 1998 at the site as part of this investigation:

- Drilled 6 soil borings (SB1-SB6);
- Collected 13 subsurface soil samples for field headspace screening and submitted 6 soil samples to a fixed-base laboratory for analysis;
- Collected groundwater samples for field and fixed-base laboratory analysis from 4 existing groundwater monitoring wells (MWs) and 3 newly-installed monitoring points (MPs); and
- Collected 2 surface water samples for laboratory analysis.

Soil and groundwater samples were analyzed in the field and at laboratories operated by Quanterra, Inc. of Arvada, Colorado and Austin, Texas. The laboratory data sheets and chain-of-custody records are presented in Appendix A. The analytical protocols for all samples are summarized in Table 2.1. Tables 2.2 and 2.3 summarize the field and fixed-base laboratory analyses performed by sampling location. These analyses and measurements were performed for various organic, inorganic, geochemical, and physical parameters to assess the current magnitude and extent of contamination and document natural biodegradation processes.

## 2.2 SUBSURFACE SOIL SAMPLING

Soil samples were collected from the site to obtain soil total organic carbon (TOC) data, to facilitate evaluation of the potential for contaminant partitioning from soil into groundwater, and to assess the magnitude of any changes in contaminant concentrations that have occurred over time. The soil boring locations are shown on Figure 2.1. These borings were advanced using a Geoprobe® hydraulic sampling rig as described in the SAP (Parsons ES, 1997a).

Samples from 6 borings were described for lithology and field screened for volatile organic vapors using a photoionization detector (PID). Six soil samples from the 6 borings were submitted to Quanterra, Inc. for laboratory analysis. Boring logs are included in Appendix C. Laboratory analyses for each soil sampling location are summarized in Table 2.2. Soil analytical results are summarized and discussed in Sections 4 and 5.

## 2.3 GROUNDWATER SAMPLING

Groundwater samples were collected from 4 existing MWs and 3 newly-installed MPs at the site in December 1998 (Figure 2.1). The groundwater samples were analyzed for fuel-related contaminants and for various inorganic and geochemical indicators to evaluate natural chemical and physical attenuation processes that are occurring at the site. Field and laboratory analyses for each groundwater sampling location are summarized in Table 2.3.

All MWs and permanently installed MPs were purged using a peristaltic pump with dedicated high-density polyethylene (HDPE) and silicone tubing. Purging consisted of removing groundwater from the well until the pH, dissolved oxygen (DO) concentration, oxidation/reduction potential (ORP), conductivity, and temperature stabilized.

**TABLE 2.1**  
**ANALYTICAL PROTOCOL FOR**  
**GROUNDWATER, SOIL, AND SURFACE WATER SAMPLES**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

MATRIX	METHOD	WHERE ANALYZED
<b>GROUNDWATER</b>		
Ferrous Iron ( $\text{Fe}^{+2}$ )	Colorimetric, Hach Method 8146	Field
Sulfate ( $\text{SO}_4^{-2}$ )	Colorimetric, Hach Method 8051	Field
Ammonium	Chemetrics Method (K-1510)	Field
Alkalinity	Titrometric, Hach Method 8221	Field
Conductivity	Direct reading meter	Field
Dissolved Oxygen	Direct reading meter	Field
pH	Direct reading meter	Field
Redox Potential	Direct reading meter	Field
Temperature	Direct reading meter	Field
Volatile organic compounds (VOCs)	602	Quanterra <sup>a/</sup>
Semivolatile Organic Compounds (SVOCs)	625	Quanterra
Polynuclear aromatic hydrocarbons (PAHs)	SW8310	Quanterra
VPH/EPH <sup>b/</sup>	MADEP <sup>c/</sup> VPH/EPH	Specialized Assays <sup>d/</sup>
Methane ( $\text{CH}_4$ )	RSK-175	Quanterra
Nitrate as Nitrogen ( $\text{NO}_3^{-1}$ -N)	E300.0/SW9056	Quanterra
<b>SOIL</b>		
VOCs	SW8260	Quanterra
SVOCs	SW8270	Quanterra
VPH/EPH	VPH/EPH	Specialized Assays
TRPH <sup>e/</sup>	E418.1	Quanterra
Total Organic Carbon	SW9060	Quanterra
<b>SURFACE WATER</b>		
Aromatic VOCs	602	Quanterra

Notes:

<sup>a/</sup> Quanterra, Inc. of Arvada, Colorado and Austin, Texas (methane only).

<sup>b/</sup> VPH = volatile petroleum hydrocarbons, EPH = extractable petroleum hydrocarbons.

<sup>c/</sup> MADEP = Massachusetts Department of Environmental Protection.

<sup>d/</sup> Specialized Assays, Inc. of Nashville, TN.

<sup>e/</sup> TRPH = total recoverable petroleum hydrocarbons.

**TABLE 2.2**  
**SOIL ANALYSES BY SAMPLE LOCATION**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

ANALYTE <sup>b/</sup>	Sample Location and Depth (ft. bgs) <sup>a/</sup>					
	SB1	SB2	SB3	SB4	SB5	SB6
	9.5	12	12	12	12	12
VOCs		X	X	X		
SVOCs		X	X	X		
VPH/EPH		X		X		
TOC					X	X
TRPH	X					

Notes:

a/ ft. bgs = feet below ground surface.

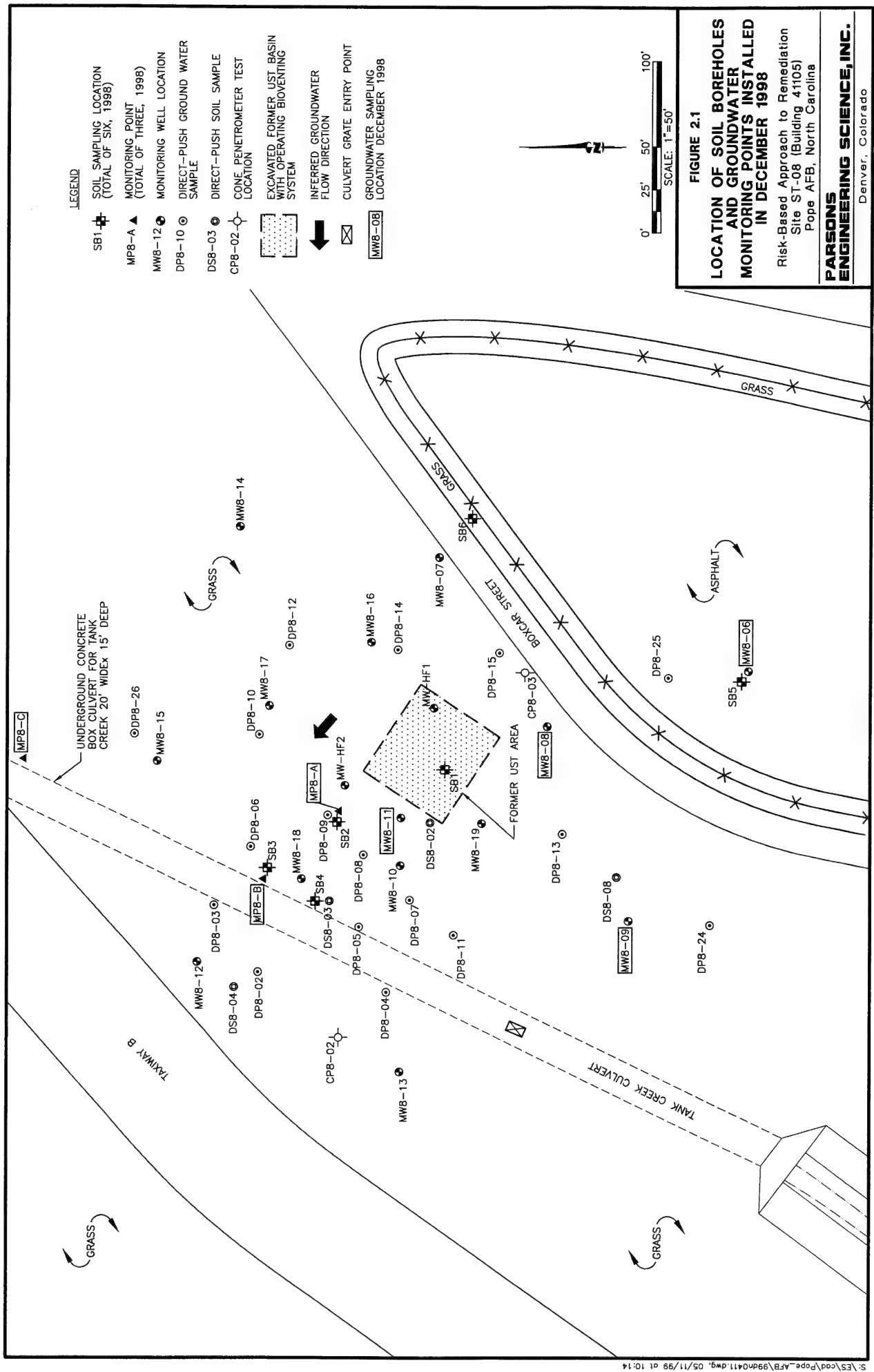
b/ VOCs = volatile organic compounds; SVOCs = semivolatile organic compounds; VPH/EPH = volatile petroleum hydrocarbons/extractable petroleum hydrocarbons; TOC = total organic carbon; TRPH = Total recoverable petroleum hydrocarbons.

**TABLE 2.3**  
**GROUNDWATER AND SURFACE WATER ANALYSES BY SAMPLE LOCATION**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

ANALYTE <sup>a/</sup>	Sample Location							
	Groundwater							Surface Water
	MP8-A	MP8-B	MP8-C	MW8-6	MW8-8	MW8-9	MW8-11	SW1
VOCs	X	X	X		X		X	X
SVOCs	X	X			X			
VPH/EPH	X							
Methane	X	X		X		X	X	
Nitrate	X	X		X		X	X	
ORP	X	X	X	X	X	X	X	
Conductivity	X	X	X	X	X	X	X	
Dissolved Oxygen	X	X	X	X	X	X	X	
Temperature	X	X	X	X	X	X	X	
pH	X	X	X	X	X	X	X	
Ferrous Iron	X	X	X	X	X	X	X	
Sulfate	X	X	X	X	X	X	X	
Ammonium	X	X	X	X	X	X	X	
Alkalinity	X	X	X	X	X	X	X	

Notes:

<sup>a/</sup> VOCs = volatile organic compounds; SVOCs = semivolatile organic compounds; VPH/EPH = volatile petroleum hydrocarbons/extractable petroleum hydrocarbons; ORP = oxidation-reduction potential.



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**FIGURE 2.1**  
**LOCATION OF SOIL BOREHOLES**  
**AND GROUNDWATER**  
**MONITORING POINTS INSTALLED**  
**IN DECEMBER 1998**  
 Risk-Based Approach to Remediation  
 Site ST-08 (Building 41105)  
 Pope AFB, North Carolina

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Within 24 hours of the purge event, groundwater samples were collected from the MWs and MPs using a peristaltic pump and dedicated tubing. The water was carefully poured down the inner walls of each sample bottle to minimize aeration of the sample. Sample bottles for VOCs, volatile petroleum hydrocarbons (VPH), methane, and/or Hach® field analyses were filled so that there was no headspace or air bubbles within the container.

Field and laboratory groundwater analytical results are discussed in Sections 4 through 6 of this report. These results are used in Section 6 to evaluate the natural physical, chemical, and biological processes that are affecting the chemicals of potential concern (COPCs) at this site.

## **2.4 SURFACE WATER SAMPLING**

Surface water samples were collected from Tank Creek at two locations and analyzed for aromatic VOCs using US Environmental Protection Agency (USEPA) Method 602. One sample was collected approximately 300 feet southwest (upstream) of the site where Tank Creek enters Tank Creek Culvert, and the other sample was collected approximately 900 feet northwest (downstream) of the site where Tank Creek exits Tank Creek Culvert. The samples were collected by lowering a clean 8-ounce (oz) glass jar into the flow, filling the jar, and gently transferring the collected water into a 40-milliliter (ml) vial.

## **2.5 EQUIPMENT DECONTAMINATION PROCEDURES**

All downhole soil sampling tools (e.g., Geoprobe® drive-shoe and sampling barrel) were cleaned prior to collection of each sample with a clean water/phosphate-free detergent mix followed by a clean water rinse. Decontaminated tools also were used for soil gas sampling. The water level indicator probe was decontaminated prior to each use with a clean water/phosphate-free detergent mix followed by a distilled water rinse.

## **2.6 INVESTIGATION-DERIVED WASTES**

Soil cuttings, unused soil samples, and purged groundwater were containerized in clean 55-gallon drums and moved to an approved on-Base storage area for later disposal by the Base.

## **2.7 SURVEYING**

The horizontal location and top-of-casing elevation of each of the newly installed groundwater MPs were surveyed by the Parsons ES field crew using previously-surveyed MWs as benchmarks. Soil borings were also located relative to existing MWs using a tape measure.

## **2.8 ANALYTICAL DATA QUALITY ASSESSMENT**

An electronic Level III validation was performed on the December 1998 analytical results obtained from Quanterra and Air Toxics to determine data quality. The validation included internal data checks and application of data qualifiers to the



analytical results based on adherence to method protocols and project-specific control limits. The electronic validation aided in assessing the quality of the data; however, professional judgement was used in applying qualifiers. A data quality assessment report is provided in Appendix F.

## **SECTION 3**

### **PHYSICAL CHARACTERISTICS OF THE STUDY AREA**

This section describes the physical characteristics of Site ST-08 and adjacent environs at Pope AFB, as determined from data collected during the CSA (URS Greiner, 1998) and by Parsons ES in December 1998 as part of the risk-based investigation. A summary of site characterization activities completed by Parsons ES to supplement existing data is presented in Section 2.

#### **3.1 REGIONAL GEOLOGY AND HYDROGEOLOGY**

The stratigraphy beneath Pope AFB consists of sands, silts, and clays of the Middendorf and Cape Fear Formations. Quaternary-age alluvium consisting of sand, gravel, silt, and clay locally overlies these formations around stream valleys. The Middendorf Formation is characterized as unconsolidated to semi-consolidated fine to coarse sands, with interbedded lenses of clay and silt, that are brownish-gray to pale gray in color. Portions of these sediments may be mottled with an orange cast. Clay balls and iron-cemented concretions are common within this formation. The Cape Fear Formation, which underlies the Middendorf Formation, was encountered at depths of 4 to 33 feet bgs during previous investigations at Pope AFB (Metcalf & Eddy, 1993). The Cape Fear Formation is composed of discontinuous layers of pale gray to gray, micaceous, silty sand, sandy silt, clayey silt, and silty clay that are densely packed, stiff, and slightly to moderately plastic. The thickness of the Coastal Plain sediments averages about 90 feet in the vicinity of the Base. These sediments unconformably overlie metamorphosed crystalline and volcanoclastic rocks of the Carolina Slate Belt in this region (URS Greiner, 1998).

Sediments of the Coastal Plain physiographic province are grouped into regional aquifers based on lithologic, hydraulic, and water quality characteristics. Groundwater beneath Pope AFB occurs within two principal aquifer systems. The Cretaceous aquifer system includes water-bearing zones of the Middendorf and Cape Fear Formations. The water table aquifer can occur in either of these formations, or within the veneer of Quaternary alluvial sediments (where present), based on topographic elevation and proximity to streams. The second aquifer system is the underlying crystalline bedrock unit. Groundwater occurs in fractures in this unit; water supply wells screened in the fractured rock aquifer typically have lower yields than wells screened in the sands of the Cretaceous aquifer system.

#### **3.2 SITE GEOLOGY AND HYDROGEOLOGY**

Lithologic logs for the soil borings installed during the pilot-scale bioventing installation (Parsons ES, 1995) show that the upper 8 feet of the soil column is

generally composed of silty to clayey sands and sandy clay, mixed with backfill material in the former UST excavation. A permeable, fine-sand layer with strong fuel odors was encountered between 8 and 10.5 feet bgs, and a layer of gray clay was encountered at 10.5 to 12 feet bgs in two borings.

During Parsons ES's (1994) preliminary screening of the site, water-saturated soils were detected at approximately 13 feet bgs in the soil borings. During the UST removals in 1992, Pope AFB personnel reported that water was seeping into the open excavation at estimated depths of 12 to 14 feet bgs. Based on these observations, Parsons ES estimated that the water table was approximately 13 to 14 feet bgs near the center of the site. The water table is typically highest in this region during the winter months, and seasonal water table fluctuations of several feet are common (Parsons ES, 1995).

In December 1998, water table depths at the site ranged from about 12 feet bgs to 19 feet bgs (Table 3.1). Groundwater in the surficial aquifer generally flows to the west and northwest under water table conditions (Figure 3.1). The water table contours indicate that groundwater migrates toward the Tank Creek culvert from the former UST area, and then in a northeasterly direction parallel to the culvert. The backfill surrounding the culvert may represent a preferential groundwater migration pathway. A representative water table gradient at and downgradient from the former UST basin, calculated based on December 1998 groundwater elevations at wells MW8-08 and MW8-11, is 0.03 foot per foot (ft/ft).

Hydraulic conductivity (K) was estimated using data from rising-head slug tests conducted during the CSA (URS Greiner, 1998). Aquifer test results are included in Appendix B. The hydraulic conductivity of the soils comprising the surficial aquifer at Site ST-08 is estimated to range from 0.58 foot per day (ft/day) to 15.19 ft/day and average 3.3 ft/day. This value also is similar to the average K computed from 18 hydrocone tests conducted during the CSA (1.8 ft/day). The hydraulic conductivity of the backfill surrounding the Tank Creek culvert may be higher than that of the native materials; however, data for the backfill is not available.

Using an average K of 3.3 ft/day, an estimated effective porosity ranging from 0.15 to 0.30 ( $n_e$ ), and a representative hydraulic gradient of 0.05 ft/ft, the estimated linear groundwater flow velocity ranges from 0.33 to 0.66 ft/day (120 to 240 feet per year).

### **3.3 SITE TOPOGRAPHY AND SURFACE WATER HYDROLOGY**

The area has relatively flat topography, with a gentle slope toward Tank Creek Culvert, and ground elevations of approximately 195 feet above mean sea level (msl).

Surface waters in the vicinity of Pope AFB include the Little River, located 0.5 to 1 mile north of the Base; McPherson Creek, located 1 mile west of the Base; and Tank Creek, which flows north through the Base. Surface water hydrology around the site is dominated by Tank Creek, which is located approximately 300 feet southwest and 900 feet northwest of the site (Figure 3.1). Overland flow at the Base is collected in a surface water drainage network. This network includes diversion structures, drainage ditches, and Tank Creek and its tributaries. Ultimately, Tank Creek discharges into the Little River. In the northwestern portion of the Base, overland flow drains directly into

**TABLE 3.1**  
**GROUNDWATER ELEVATIONS - DECEMBER 1, 1998**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Location	TOC <sup>a/</sup> Elevation (ft msl) <sup>b/</sup>	Depth to LNAPL <sup>c/</sup> (ft below TOC)	Depth to Water (ft below TOC)	Groundwater Elevation (ft msl)
MPA	192.55	-- <sup>d/</sup>	15.99	176.56
MPB	190.85	--	14.84	176.01
MPC	191.3	--	14.13	177.17
MW8-6	195.74	--	12.20	183.54
MW8-7	195.53	--	12.09	183.44
MW8-8	196.42	--	12.25	184.17
MW8-9	195.98	--	13.86	182.12
MW8-10	193.24	--	16.93	176.31
MW8-11	194.88	--	18.68	176.20
MW8-12	191.71	--	15.31	176.40
MW8-13	191.14	--	12.78	178.36
MW8-14	192.17	--	14.13	178.04
MW8-15	191.59	--	13.76	177.83
MW8-16	195.19	--	18.68	176.51
MW8-17	193.13	--	15.51	177.62
MW8-18	191.41	14.09	15.79	--
MW8-19	195.79	LNAPL Present <sup>e/</sup>	18.84	176.95
MWHF2	NA <sup>f/</sup>	--	16.86	--
MWHF1	NA	13.04	14.00	--

Notes:

<sup>a/</sup> TOC = top of PVC casing.

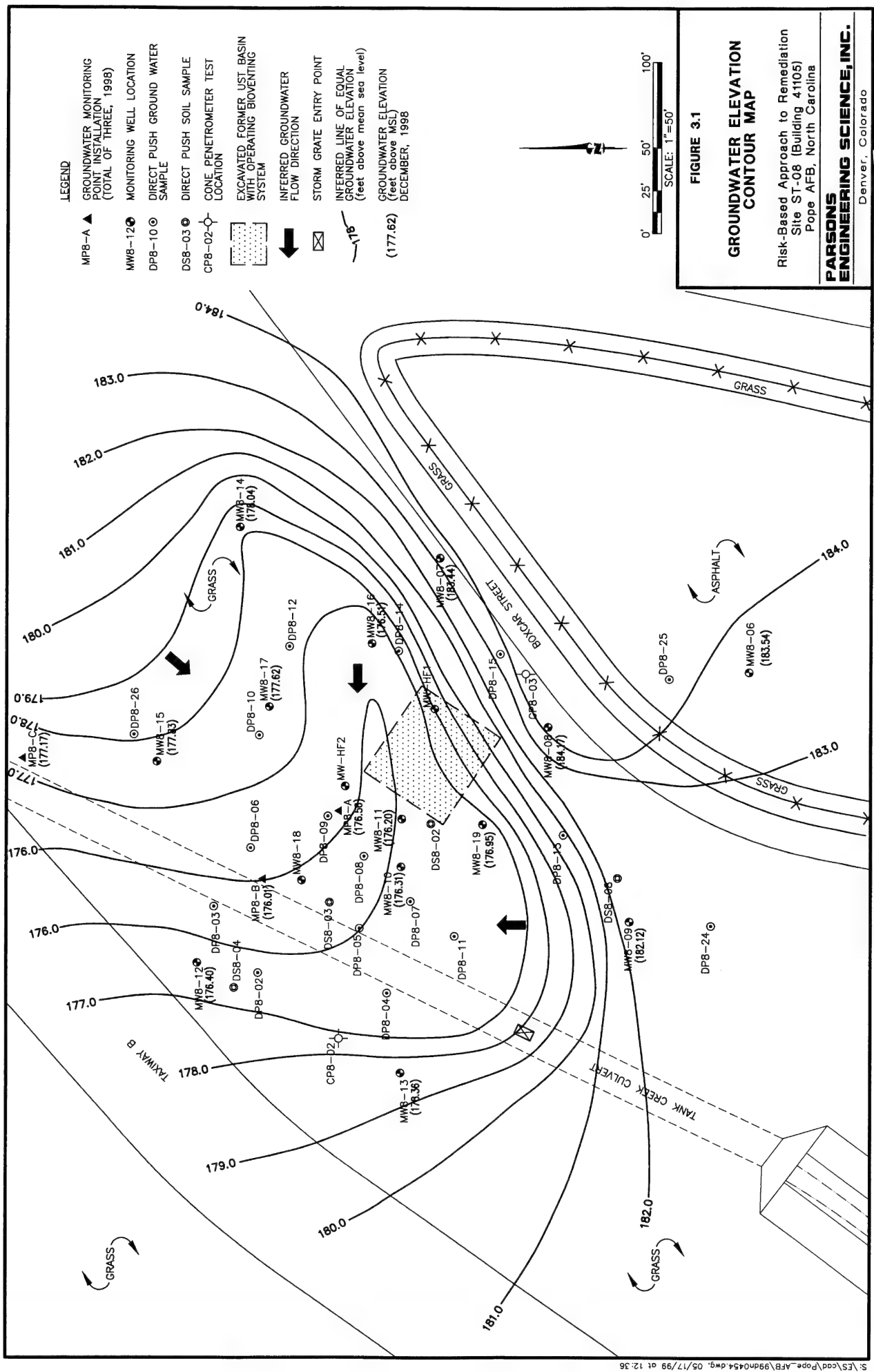
<sup>b/</sup> ft msl = feet above mean sea level.

<sup>c/</sup> LNAPL = light non-aqueous phase liquid.

<sup>d/</sup> -- = LNAPL not present.

<sup>e/</sup> = LNAPL present in the form of beads on the measuring probe.

<sup>f/</sup> NA = Not available.



**LEGEND**

- MP8-A ▲ GROUNDWATER MONITORING POINT INSTALLATION (TOTAL OF THREE, 1998)
- MWB-12 ● MONITORING WELL LOCATION
- DP8-10 ⊙ DIRECT PUSH GROUND WATER SAMPLE
- DS8-03 ⊕ DIRECT PUSH SOIL SAMPLE
- CP8-02 ⊖ CONE PENETROMETER TEST LOCATION
- EXCAVATED FORMER UST BASIN WITH OPERATING BIOVENTING SYSTEM
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM GRATE ENTRY POINT
- INFERRED LINE OF EQUAL GROUNDWATER ELEVATION (feet above mean sea level)
- GROUNDWATER ELEVATION (177.62) (feet above MSL) DECEMBER, 1998



**FIGURE 3.1**

**GROUNDWATER ELEVATION CONTOUR MAP**

Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

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the Little River and its tributaries. Both Tank Creek and the Little River are classified by the State of North Carolina as Class C waters. Class C waters are suitable for secondary contact, recreation, and fish and wildlife propagation (URS Greiner, 1998).

### **3.4 WATER WELL SURVEY RESULTS**

The nearest water supply well (PSW40) is located about 6,000 feet east of (upgradient from) the site. This well has no influence on the site's groundwater flow direction. Groundwater in the vicinity of Site ST-08 is not extracted for any beneficial use. Pope AFB potable water is provided via Fort Bragg, which draws and treats water from the Little River.

## **SECTION 4**

### **TIER 1 ANALYSIS AND IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN**

This section provides an overview of the regulatory requirements for a risk-based, tiered approach to identification of COPCs, and reviews the preliminary conceptual site model (CSM) developed for Site ST-08 in the work plan (Parsons ES, 1998). The CSM was used to select appropriate regulatory screening criteria and to identify COPCs in affected site media (i.e., chemicals present at concentrations that could pose a risk to human and/or ecological receptors exposed to the affected media). This section also presents a Tier 1 analysis used to identify the COPCs. The COPCs for the site are identified in the Tier 1 analysis based on estimated risks to human health posed by maximum detected contaminant concentrations.

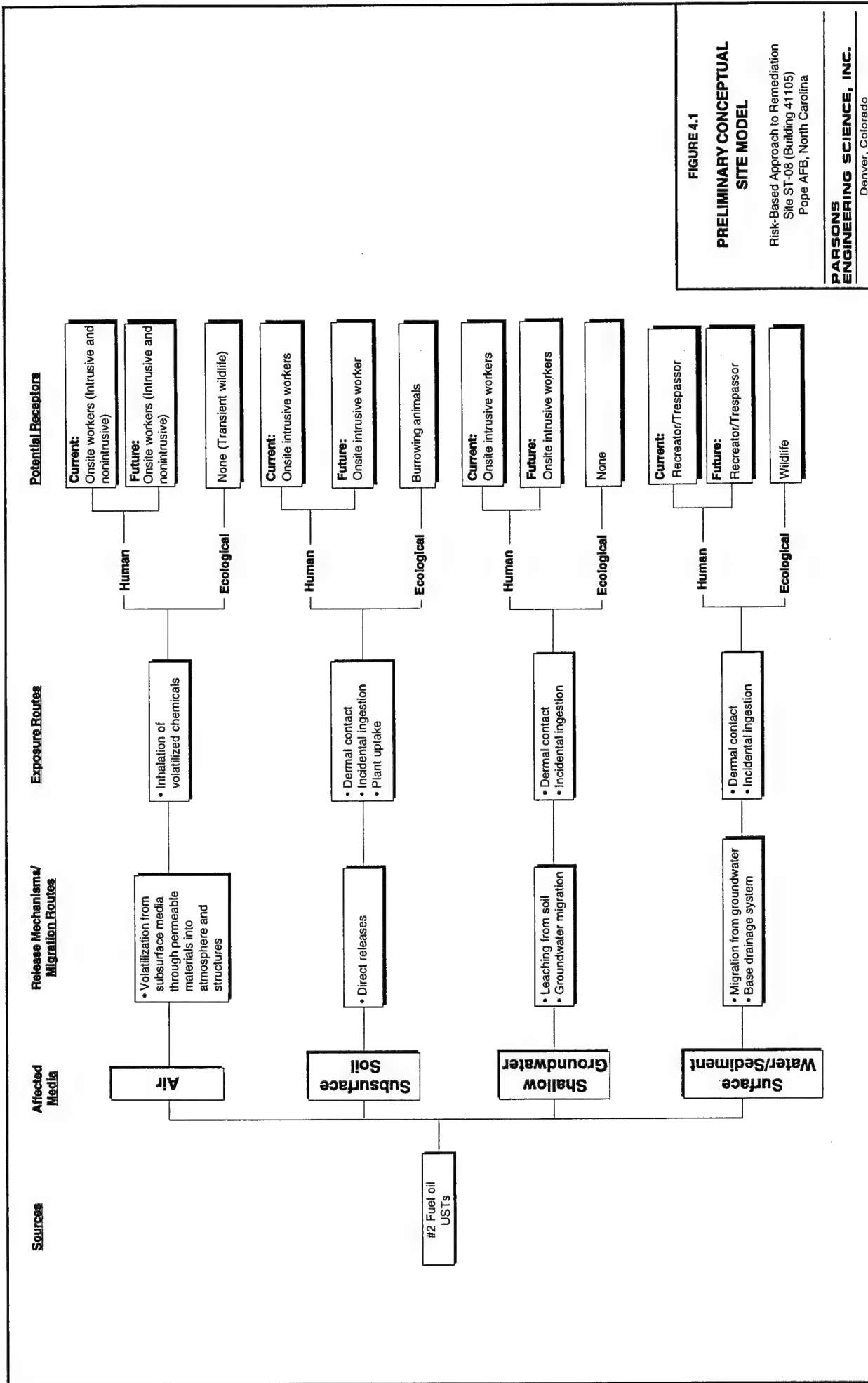
#### **4.1 REGULATORY REVIEW OF THE TIER 1 SCREENING PROCESS**

As an initial step in determining the necessity for remedial action at Site ST-08, representative concentrations of site contaminants are compared to appropriate soil and groundwater screening criteria presented in Tables 4 and 7 of the Groundwater Section Guidelines for the Investigation and Remediation of Soil and Groundwater, Volume II, Petroleum Underground Storage Tanks (USTs) (North Carolina DEHNR, 1998a). Contaminant soil concentrations must be below the Industrial/Commercial target levels presented in Table 4. Concentrations of COPCs in groundwater must be below the GCLs presented in Table 7.

Those analytes with site concentrations that exceed the appropriate criteria for soil and groundwater are considered to be COPCs, and are retained for further analysis concerning the risk-reduction requirements for the site. The nature and extent of these COPCs are described more fully in Section 5. Qualitative and quantitative fate and transport analyses are presented in Section 6 to evaluate the migration of selected contaminants in groundwater.

#### **4.2 PRELIMINARY CONCEPTUAL SITE MODEL REVIEW**

Figure 4.1 presents the preliminary CSM developed for the site. The model was developed using data collected during previous site investigations and is based on a review of potential receptors and feasible exposure scenarios. The purpose of developing a CSM is to guide the evaluation of available site information, including:





- Potential contaminant sources;
- Mechanisms of contaminant release (e.g., leaching and volatilization) and potential migration routes;
- Media affected by contaminant releases;
- Routes of possible receptor exposure (e.g., inhalation, ingestion, or dermal contact); and
- Potential human and ecological receptors based on conservative, reasonable land use assumptions.

The CSM also was developed to provide an outline for addressing all media-specific current and future exposure scenarios at the site. The CSM has been constructed to identify potentially completed receptor exposure pathways. For an exposure pathway to be completed, there must be a contaminant source, a release mechanism, a contaminant migration pathway, an exposure route, and a receptor. If any of these components is missing, the pathway is considered incomplete, and receptors are not at risk from exposure to site contaminants.

#### **4.2.1 Potential Contaminant Sources, Release Mechanisms, and Affected Media**

As shown on Figure 1.3, the source of contamination at Site ST-08 is believed to be the No. 2 fuel oil UST(s). In 1990, a precision test on the four USTs confirmed that one of the tanks was leaking. Continuing release mechanisms may include volatilization of hydrocarbons from soil and groundwater into the atmosphere, partitioning of hydrocarbons from contaminated soil into groundwater, and discharge of contaminated groundwater into Tank Creek Culvert. Air, soil, shallow groundwater, and surface water in Tank Creek (Figure 1.2), are the potentially affected physical media at or downgradient from the site.

#### **4.2.2 Potential Exposure Routes**

An understanding of potential exposure pathways is important in determining how potential receptors could contact contaminated media and how that contact could result in the uptake of chemicals. Potential exposure routes by which contaminants could impact potential receptors include the following:

- Uptake of contamination from soil by local vegetation;
- Dermal contact with or incidental ingestion of contaminated soil by site workers (e.g., during excavation activities);
- Inhalation of volatilized contaminants by site workers;
- Dermal contact with or incidental ingestion of contaminated groundwater by site workers during high water periods (e.g., during excavation activities); and

- Dermal contact with or incidental ingestion of contaminated surface water by receptors or recreators in or along Tank Creek.

#### **4.2.3 Land Use and Potential Receptors**

On the basis of available site-specific information, current and future land use at the site is assumed to be industrial/commercial as opposed to residential. The site is an undeveloped area adjacent a motor pool parking lot (across Boxcar Street) and Taxiway B. Access to the site is restricted due to the proximity of the taxiway and runway. Potential receptors include onsite intrusive and non-intrusive workers, site vegetation, and wildlife. It should be noted that the water table depth throughout the site is typically greater than 12 feet, which is the typical maximum excavation depth for building foundations. Therefore, intrusive workers would only be exposed to groundwater during wet periods characterized by unusually high water levels. The surface water in Tank Creek, located approximately 900 feet north of the site, is not classified as a fishery, but public access to Tank Creek is not restricted. Therefore, trespassers or recreators in Tank Creek also are potential receptors.

#### **4.3 TIER 1 SCREENING ANALYSIS**

It is the intention of the Air Force to obtain North Carolina DEHNR approval for a corrective action for the site that will protect potential receptors from unacceptable exposures to site-related chemicals. To accomplish this objective, the COPCs that drive potential risks and impact the final remedial requirements at this site were identified.

North Carolina DEHNR (1998a) Tier 1 screening criteria are based on 1) analyte-specific toxicity data; 2) an exposure-pathway-specific cancer target risk limit of  $10^{-6}$  (i.e., one additional cancer above the background rate in a population of one million) and a noncancer hazard quotient limit of 0.2; and 3) conservative receptor exposure assumptions.

##### **4.3.1 Tier 1 Screening Analysis for Soil**

Industrial/commercial screening criteria were selected as the appropriate set of Tier 1 screening values for soil at the site. The North Carolina DEHNR (1998a) guidance provides industrial/commercial screening levels for petroleum constituents in soil that incorporate risks posed by the ingestion pathway. Table 4.1 compares the maximum concentrations for each compound measured in soil at the site during the December 1998 risk-based sampling event to the industrial/commercial screening criteria. Based on these comparisons, there are no constituents identified as COPCs in soil.

The maximum sample-specific reporting and detection limits for 1,2-dibromoethane (ethylene dibromide [EDB]) are both greater than the screening level for this compound. Therefore, this compound cannot be ruled out as a COPC with certainty. However, 1,2-dibromomethane was not detected in any of the soil samples collected in December 1998, nor was it detected during the CSA (URS Greiner 1998). The lack of detections throughout the site indicates that this compound is not a COPC in site soils.

**TABLE 4.1**  
**TIER 1 SCREENING SUMMARY FOR SOIL**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Analyte	Units	Maximum Concentration 1-Dec-98	Location (and Depth Interval in ft bgs) of Concentration	Industrial/ Commercial Screening Level <sup>a/</sup>
Benzene	mg/kg <sup>b/</sup>	0.0048 J1 <sup>c/</sup>	SB3-12	200
Ethylbenzene	mg/kg	6 J <sup>d/</sup>	SB2-12	40,000
Toluene	mg/kg	5.3 UJ <sup>e/</sup>	NA <sup>f/</sup>	82,000
Xylenes (total)	mg/kg	47.6 J	SB2-12	200,000
Aliphatics				
C5-C8	mg/kg	831	SB4-12	24,528
C9-C18	mg/kg	3,550	SB2-12	245,280
C19-C36	mg/kg	356	SB2-12	NA
Aromatics				
C9-C22	mg/kg	1,914	SB2-12	12,264
Acenaphthene	mg/kg	0.56 J1	SB4-12	24,000
Acenaphthylene	mg/kg	0.86 U <sup>g/</sup>	NA	12,264
Anthracene	mg/kg	0.57 J1	SB4-12	122,000
Benzo(a)anthracene	mg/kg	0.45 J1	SB4-12	8
Benzo(a)pyrene	mg/kg	0.24 J1	SB4-12	0.78
Benzo(b)fluoranthene	mg/kg	0.21 J1	SB4-12	8
Benzo(g,h,i)perylene	mg/kg	0.86 U	NA	12,264
Benzo(k)fluoranthene	mg/kg	-- <sup>h/</sup>	--	78
n-Butylbenzene	mg/kg	7.9 J	SB2-12	4,088
sec-Butylbenzene	mg/kg	3.9 J	SB2-12	4,088
tert-Butylbenzene	mg/kg	7.4 UJ	NA	4,088
n-Propylbenzene	mg/kg	4.4 J	SB2-12	4,088
Chlorobenzene	mg/kg	2.1 UJ	NA	NA
Chrysene	mg/kg	0.43 J1	SB4-12	780
Dibenz(a,h)anthracene	mg/kg	0.86 U (0.16) <sup>i/</sup>	NA	0.78
1,2-Dibromoethane	mg/kg	3.2 UJ (1.2)	SB2-12	0.067
1,2-Dichlorobenzene	mg/kg	2.1 UJ	NA	36,000
1,3-Dichlorobenzene	mg/kg	6.3 UJ	NA	36,000
1,4-Dichlorobenzene	mg/kg	2.1 UJ	NA	240
1,1-Dichloroethane	mg/kg	2.1 UJ	NA	40,000
1,2-Dichloroethane	mg/kg	3.2 UJ	NA	63
1,1-Dichloroethene	mg/kg	6.3 UJ	NA	10
1,2-Dichloroethene (cis)	mg/kg	6.3 UJ	NA	4,000
1,2-Dichloroethene (trans)	mg/kg	3.2 UJ	NA	8,200
1,2-Dichloropropane	mg/kg	2.1 UJ	NA	84
1,3-Dichloropropene (cis and trans)	mg/kg	5.3 UJ	NA	33
Fluoranthene	mg/kg	1.3	SB4-12	16,400
Fluorene	mg/kg	0.93	SB4-12	16,400
Indeno(1,2,3-cd)pyrene	mg/kg	0.86 U	NA	8.0
Isopropyl benzene	mg/kg	3.5 J	SB2-12	40,880
Isopropyl ether	mg/kg	--	--	4,088
2-Methylnaphthalene	mg/kg	4	SB4-12	1,635
MTBE	mg/kg	--	--	4,088
Naphthalene	mg/kg	22 J	SB2-12	1,635
Phenanthrene	mg/kg	2.7	SB4-12	12,264
Pyrene	mg/kg	1.3	SB4-12	12,264
1,2,4-Trimethylbenzene	mg/kg	47 J	SB2-12	20,440
1,3,5-Trimethylbenzene	mg/kg	25 J	SB2-12	20,440

Notes:

- a/ Target cleanup levels from North Carolina DEHNR (1998a).  
b/ mg/kg = Milligrams per kilogram.  
c/ J1 = This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.  
d/ J = The analyte was positively identified, but the value may not be representative of what is actually present.  
e/ UJ = The analyte was not detected above the practical quantitation limit (PQL). The value used may not be representative of the actual concentration.  
f/ NA = Not available.  
g/ U = The analyte was analyzed for and is not present above the associated reporting limit.  
h/ -- = analyte not targeted for analysis.  
i/ In cases where the maximum sample reporting limit exceeds the target cleanup level, the sample-specific method detection limit (MDL) is given in parentheses. The analyte concentration is less than the MDL.

The maximum soil contaminant concentrations were not compared to the residential screening criteria presented in Table 4 of North Carolina DEHNR (1998a). The residential screening criteria were established to protect the health of children and adult residents that may be exposed to contaminated soil. Soil concentrations also were not compared to soil-to-groundwater screening criteria due to the current and expected future industrial land use at this site. The soil-to-groundwater criteria were established to ensure that leaching of residual contamination adsorbed to soil particles will not result in groundwater contaminant concentrations that exceed drinking water standards, therefore these criteria are not appropriate for this site.

#### **4.3.2 Tier 1 Screening Analysis for Groundwater**

The Tier 1 GCLs for groundwater presented by the North Carolina DEHNR (1998a) are compared to maximum dissolved contaminant concentrations detected in December 1998 in Table 4.2. Based on these comparisons, dissolved concentrations of benzo(b)fluoranthene and benzo(k)fluoranthene are identified as COPCs in groundwater at Site ST-08 based on the slight exceedance of the GCLs for these compounds. Although the C5-C8 and C9-C18 aliphatics and the C9-C22 aromatics exceed their respective interim groundwater standards published in 15A NCAC 26, these standards are not considered appropriate for the existing land use identified at Site ST-08. Because there are no GCLs established for these classes of compounds, they are not considered to be COPCs.

#### **4.3.3 Tier 1 Screening Analysis for Surface Water**

All surface waters in North Carolina are assigned a primary classification by the North Carolina Division of Water Quality. All waters must at least meet the standards for Class C (fishable/swimmable) waters. The other primary classifications provide additional levels of protection for primary contact recreation (Class B) and drinking water (Water Supply Classes I through V). The analytical results for the surface water samples obtained from Tank Creek (Section 2.4) were compared to Class C surface water standards to assess the presence of COPCs. The only petroleum hydrocarbon compound represented in the Class C standards is toluene, which has a standard of 11 micrograms per liter ( $\mu\text{g/L}$ ). Toluene was not detected in either sample at a reporting limit of 0.5  $\mu\text{g/L}$ . Detectable concentrations of other targeted aromatic VOCs also were not present. Therefore, there are no COPCs in surface water.

#### **4.3.4 Summary of Site COPCs**

Based on comparisons of the maximum soil, surface water, and groundwater concentrations to North Carolina DEHNR (1998a) screening criteria and Division of Water Quality surface water standards, dissolved benzo(b)fluoranthene and benzo(k)fluoranthene in groundwater are the only constituents identified as COPCs for Site ST-08.

**TABLE 4.2**  
**TIER 1 SCREENING SUMMARY FOR GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Analyte	Units	Maximum Detection	Detection Location	GCL <sup>a/</sup>
Benzene	µg/L <sup>b/</sup>	30	MP8-11	5,000
Ethylbenzene	µg/L	220	MP8-A	29,000
Toluene	µg/L	100	MP8-A	257,500
Xylenes (total)	µg/L	950	MP8-A	87,500
Aliphatics				
C5-C8	µg/L	2,370	MP8-A	0.42 <sup>c/</sup>
C9-C18	µg/L	2,689	MP8-A	4.2 <sup>c/</sup>
C19-C36	µg/L	100 U	MP8-A	42 <sup>c/</sup>
Aromatics				
C9-C22	µg/L	2,022	MP8-A	0.21 <sup>c/</sup>
Acenaphthene	µg/L	6.4 J1 <sup>d/</sup>	MP8-A	2,120
Acenaphthylene	µg/L	10 U <sup>e/</sup>	NA <sup>f/</sup>	1,965
Anthracene	µg/L	3.5 J <sup>g/</sup>	MP8-A	645
Benzo(a)anthracene	µg/L	10 U	NA	22.0
Benzo(a)pyrene	µg/L	1.1 J	MP8-A	1.5
Benzo(b)fluoranthene	µg/L	1 J	MP8-A	0.6
Benzo(g,h,i)perylene	µg/L	10 U	NA	210
Benzo(k)fluoranthene	µg/L	0.7 J	MP8-A	0.5
Chlorobenzene	µg/L	5.8	MP8-B	50,000
Chrysene	µg/L	1 UJ	NA	5
Dibenz(a,h)anthracene	µg/L	1.5 UJ (0.25) <sup>h/</sup>	NA	0.3
1,2-Dichlorobenzene	µg/L	6.9	MP8-B	72,500
1,3-Dichlorobenzene	µg/L	8	MP8-B	61,500
1,4-Dichlorobenzene	µg/L	13 J	MP8-B	39,500
2,4-Dimethyl phenol	µg/L	4.1 J1	MP8-A	NA
Fluoranthene	µg/L	20 J	MP8-A	280
Fluorene	µg/L	7.8 J1	MP8-A	950
Indeno(1,2,3-cd)pyrene	µg/L	10 U	NA	31.0
MTBE	µg/L	NA	NA	200,000
Naphthalene	µg/L	180 J	MP8-A	15,500
Phenanthrene	µg/L	27 J	MP8-A	410
Pyrene	µg/L	1.5 J1	MP8-A	210
1,2,4-Trimethylbenzene	µg/L	NA	NA	28,500

Notes: Shaded area denotes that detected concentration exceeds the GCL for that contaminant.

a/ GCL = gross contaminant level [North Carolina DEHNR (1998a)]

b/ µg/L = micrograms per liter.

c/ Interim Groundwater Standard (15A NCAC 26).

d/ J1 = This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.

e/ U = the analyte was analyzed for and is not present above the associated reporting limit.

f/ NA = not available.

g/ J = This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.

h/ In cases where the maximum sample reporting limit exceeds the target cleanup level, the sample-specific method detection limit (MDL) is given in parentheses. The analyte concentration is less than the MDL.

## SECTION 5

### ANALYTICAL DATA SUMMARY AND EXTENT OF CHEMICALS OF POTENTIAL CONCERN

#### 5.1 OVERVIEW

This section presents analytical results from the December 1998 field-sampling event in tabular form, and summarizes the magnitude and extent of selected constituents in sampled media at Site ST-08.

#### 5.2 SOIL SAMPLING RESULTS

Soil sampling was performed as part of the recent risk-based investigation. Field screening results are summarized in Table 5.1, and laboratory analytical results are summarized in Table 5.2. Boring logs are included in Appendix C. Soil borings were advanced in areas of elevated fuel contamination (based on previous investigations) to determine worst-case hydrocarbon concentrations in soil, in addition to facilitating evaluation of the change in concentrations over time. Soil boring locations are shown on Figure 2.1. The soil sample locations were selected based on the known location of the former USTs and analytical results for previously-collected soil samples.

A total of six soil samples were collected. One of the sampling locations is located in the release area of the former UST location (SB1), three samples were collected downgradient from the release point toward taxiway B (SB2, SB3, and SB4), and two samples were collected outside of the contaminated area (SB5 and SB6) for the purpose of obtaining native TOC concentrations. Soil borings SB1 and SB4 were located adjacent to previous soil borings PO1-MPA and DS8-03, respectively. Previous soil boring PO1-MPA was drilled and sampled by Parsons ES in February 1995 during the bioventing system installation. Previous soil boring DS8-03 was drilled and sampled by URS Greiner in January 1996 during the CSA. The intent of sampling the same location and depth interval again was to facilitate the assessment of temporal changes in contaminant concentrations in these historically contaminated areas.

As shown in Table 4.1, no contaminant concentrations exceeding the Tier 1 industrial/commercial screening levels were detected. The highest concentrations of ionizable volatile organics detected using the PID were present in the 12- to 16-ft bgs depth interval in most of the borings at the site. The highest concentrations of BTEX compounds were mostly detected in soil sample SB2, collected at 12 feet bgs, 0.5 feet above the estimated water table.

**TABLE 5.1**  
**SOIL BORING SUMMARY AND FIELD SCREENING RESULTS**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Soil Boring	Boring Date	Highest PID Measurement (ppmv) <sup>a/</sup> (Measurement Depth [ft bgs <sup>b/</sup> ])	Estimated Depth to Water (ft bgs)	Total Depth (ft bgs)
SB1	12/11/1998	<10(9.5)	NA <sup>c/</sup>	10.0
SB2	12/10/1998	>200 (12-13)	17.0	19.0
SB3	12/11/1998	400 (12-13)	12.5	12.5
SB4	12/11/1998	60 (12-13)	14.0	17.0
SB5	12/11/1998	<10 (12)	12.0	14.0
SB6	12/11/1998	<10 (12)	11.5	12.0

<sup>a/</sup> ppmv = parts per million, volume per volume; PID = photoionization detector.

<sup>b/</sup> ft bgs = feet below ground surface.

<sup>c/</sup> NA = Not available.



TABLE 5.2  
SUMMARY OF SOIL ANALYTICAL DATA  
Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

Analyte	Units	Sample Location-Depth (ft bgs), Date, and Method											
		SB2-12 12/10/1998 VOCs	SB3-12 12/11/1998 VOCs	SB3R-12 2/2/1999 VOCs	SB4-12 12/11/1998 VOCs	SB2-12 2/2/1998 SVOCs	SB3-12 2/2/1998 SVOCs	SB4-12 2/2/1998 SVOCs	SB2-12 12/10/1998 VPH/EPH	SB4-12 12/11/1998 VPH/EPH	SB1-9 12/11/1998 TRPH	SB5-12 12/11/1998 TOC	SB6-12 12/11/1998 TOC
Benzene	mg/kg <sup>a</sup>	2.1 U <sup>b</sup>	0.27 U <sup>c</sup>	0.0048 J <sup>d</sup>	0.58 U								
Ethylbenzene	mg/kg	6 J <sup>e</sup>	0.2 J <sup>f</sup>	0.045	0.87 U								
Toluene	mg/kg	5.3 U <sup>g</sup>	0.68 U	0.015 U	1.5 U								
Xylenes (total)	mg/kg	47.6 J	1.53 J <sup>i</sup>	0.123 J	0.34 J <sup>i</sup>								
Aliphatics													
C5-C8	mg/kg							770	831				
C9-C18	mg/kg							3,550	1,199				
C19-C36	mg/kg							356	10.8				
Aromatics													
C9-C22	mg/kg							1,914	460				
Total Recoverable													
Petroleum Hydrocarbons (TRPH)	mg/kg									11.2 U <sup>j</sup>			
Total Organic Carbon (TOC)	mg/kg										2,000 U	2,000 U	
Acenaphthene	mg/kg					0.81 U	0.86 U	0.56 J <sup>k</sup>					
Acenaphthylene	mg/kg					0.81 U	0.86 U	0.83 U					
Anthracene	mg/kg					0.81 U	0.86 U	0.57 J <sup>k</sup>					
Benzo(a)anthracene	mg/kg					0.81 U	0.86 U	0.45 J <sup>k</sup>					
Benzo(a)pyrene	mg/kg					0.81 U	0.86 U	0.24 J <sup>k</sup>					
Benzo(b)fluoranthene	mg/kg					0.81 U	0.86 U	0.21 J <sup>k</sup>					
Benzoic acid	mg/kg					1.8 U	2 U	1.9 U					
Benzo(g,h,i)perylene	mg/kg					0.81 U	0.86 U	0.83 U					
Benzyl alcohol	mg/kg					1.5 U	1.6 U	1.5 U					
bis(2-Chloroethoxy) methane	mg/kg					0.81 U	0.86 U	0.83 U					
bis(2-Chloroethyl) ether	mg/kg					0.81 U	0.86 U	0.83 U					
bis(2-Chloroisopropyl) ether	mg/kg					0.81 U	0.86 U	0.83 U					
bis(2-Ethylhexyl) phthalate	mg/kg					0.5 J <sup>k</sup>	0.86 U	0.83 U					
4-Bromophenyl phenyl ether	mg/kg					0.81 U	0.86 U	0.83 U					
Butyl benzyl phthalate	mg/kg					0.81 U	0.86 U	0.83 U					
Bromobenzene	mg/kg	2.1 U <sup>j</sup>	0.27 U	0.0062 U	0.58 U								
Bromochloromethane	mg/kg	2.1 U <sup>j</sup>	0.27 U	0.0062 U	0.58 U								
Bromodichloromethane	mg/kg	4.2 U <sup>j</sup>	0.54 U	0.012 U	1.2 U								
Bromoform	mg/kg	6.3 U <sup>j</sup>	0.82 U	0.018 U	1.7 U								
Bromomethane	mg/kg	5.3 U <sup>j</sup>	0.68 U	0.015 U	1.5 U <sup>j</sup>								
n-Butylbenzene	mg/kg	7.9 J	0.68 U	0.0035 J <sup>k</sup>	1.5 U								
sec-Butylbenzene	mg/kg	3.9 J	0.21 J <sup>k</sup>	0.0024 J <sup>k</sup>	2 U								
tert-Butylbenzene	mg/kg	7.4 U <sup>j</sup>	0.95 U	0.022 U	2 U								
4-Chloroaniline	mg/kg					1.5 U	1.6 U	1.5 U					
4-Chloro-3-methylphenol	mg/kg					1.5 U	1.6 U	1.5 U					
2-Chlorophenol	mg/kg					0.81 U	0.86 U	0.83 U					
4-Chlorophenyl phenyl ether	mg/kg					0.81 U	0.86 U	0.83 U					
Carbon tetrachloride	mg/kg	11 U <sup>j</sup>	1.4 U	0.031 U	2.9 U								
Chlorobenzene	mg/kg	2.1 U <sup>j</sup>	0.27 U	0.0062 U	0.58 U								
Chlorodibromomethane	mg/kg	3.2 U <sup>j</sup>	0.41 U	0.012 U	0.87 U								
Chloroethane	mg/kg	5.3 U <sup>j</sup>	0.68 U	0.015 U	1.5 U								
Chloroform	mg/kg	2.1 U <sup>j</sup>	0.27 U	0.0062 U	0.58 U								
1-Chlorohexane	mg/kg	3.2 U <sup>j</sup>	0.41 U	0.0092 U	0.87 U								
Chloromethane	mg/kg	7.4 U <sup>j</sup>	0.95 U	0.022 U	2 U								
2-Chlorotoluene	mg/kg	2.1 U <sup>j</sup>	0.27 U	0.0062 U	0.58 U								
4-Chlorotoluene	mg/kg	3.2 U <sup>j</sup>	0.41 U	0.0092 U	0.87 U								
Chrysene	mg/kg <sup>a</sup>					0.81 U	0.86 U	0.43 J <sup>k</sup>					



TABLE 5.2 (Continued)  
SUMMARY OF SOIL ANALYTICAL DATA  
Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

Analyte	Units	Sample Location-Depth (ft bgs), Date, and Method											
		SB2-12 12/10/1998 VOCs	SB3-12 12/11/1998 VOCs	SB3R-12 2/2/1999 VOCs	SB4-12 12/11/1998 VOCs	SB2-12 2/2/1998 SVOCs	SB3-12 2/2/1998 SVOCs	SB4-12 2/2/1998 SVOCs	SB2-12 12/10/1998 VPH/EPH	SB4-12 12/11/1998 VPH/EPH	SB1-9 12/11/1998 TRPH	SB5-12 12/11/1998 TOC	SB6-12 12/11/1998 TOC
Dibenzofuran	mg/kg					0.81 U	0.86 U	0.35 J1					
3,3-Dichlorobenzidine	mg/kg					1.5 U	1.6 U	1.5 U					
Dichlorodifluoromethane	mg/kg	5.3 UJ	0.68 UJ	0.015 U	1.5 UJ								
2,4-Dichlorophenol	mg/kg					0.35 U	0.37 U	0.36 U					
Diethyl phthalate	mg/kg					0.81 U	0.86 U	0.83 U					
2,4-Dimethylphenol	mg/kg					0.35 U	0.37 U	0.36 U					
Dimethyl phthalate	mg/kg					0.81 U	0.86 U	0.83 U					
4,6-Dinitro-2-methylphenol	mg/kg					3.8 U	4.1 U	3.9 U					
2,4-Dinitrophenol	mg/kg					3.8 U	4.1 U	3.9 U					
2,4-Dinitrotoluene	mg/kg					0.81 U	0.86 U	0.83 U					
2,6-Dinitrotoluene	mg/kg					0.81 U	0.86 U	0.83 U					
Di-n-octyl phthalate	mg/kg					0.81 U	0.86 U	0.83 U					
Dibenz(a,h)anthracene	mg/kg					0.81 U	0.86 U	0.83 U					
Dibromomethane	mg/kg	11 UJ	1.4 U	0.031 U	2.9 U								
1,2-Dichlorobenzene	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U	0.81 U	0.86 U	0.83 U					
1,3-Dichlorobenzene	mg/kg	6.3 UJ	0.82 U	0.018 U	1.7 U	0.81 U	0.86 U	0.83 U					
1,4-Dichlorobenzene	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U	0.81 U	0.86 U	0.83 U					
1,1-Dichloroethane	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
1,2-Dichloroethane	mg/kg	3.2 UJ	0.41 U	0.0092 U	0.87 U								
1,1-Dichloroethene	mg/kg	6.3 UJ	0.82 U	0.018 U	1.7 U								
1,2-Dichloroethene (cis)	mg/kg	6.3 UJ	0.82 U	0.018 U	1.7 U								
1,2-Dichloroethene (trans)	mg/kg	3.2 UJ	0.41 U	0.0092 U	0.87 U								
1,2-Dichloropropane	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
1,3-Dichloropropane	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
2,2-Dichloropropane	mg/kg	21 UJ	2.7 U	0.062 U	5.8 U								
1,1-Dichloropropene	mg/kg	5.3 UJ	0.68 U	0.015 U	1.5 U								
1,3-Dichloropropene (cis)	mg/kg	5.3 UJ	0.68 U	0.015 U	1.5 U								
1,3-Dichloropropene (trans)	mg/kg	5.3 UJ	0.68 U	0.015 U	1.5 U								
Fluoranthene	mg/kg					0.29 J	0.86 U	1.3					
Fluorene	mg/kg					0.23 J	0.86 U	0.93					
Hexachlorobenzene	mg/kg					0.81 U	0.86 U	0.83 U					
Hexachlorobutadiene	mg/kg	5.3 UJ	0.68 U	0.015 U	1.5 U	0.81 U	0.86 U	0.83 U					
Hexachlorocyclopentadiene	mg/kg					0.81 U	0.86 U	0.83 U					
Hexachloroethane	mg/kg					0.81 U	0.86 U	0.83 U					
Indeno(1,2,3-cd)pyrene	mg/kg					0.81 U	0.86 U	0.83 U					
Isophorone	mg/kg					0.81 U	0.86 U	0.83 U					
Isopropyl benzene	mg/kg	3.5 J	0.17 J1	0.009 J1	2.3 U	0.81 U	0.86 U	0.83 U					
p-Isopropyltoluene	mg/kg	6.3 UJ	0.82 U	0.0043 J1	1.7 U								
Methylene chloride	mg/kg	5.3 UJ	0.68 U	0.0023 U	0.39 J1								
2-Methylnaphthalene	mg/kg					1.2 R <sup>2</sup>	0.86 U	4					
2-Methylphenol	mg/kg					0.35 U	0.37 U	0.36 U					
Naphthalene	mg/kg	22 J	0.68 U	0.04	2.1	0.81 U	0.86 U	0.55 J1					
2-Nitroaniline	mg/kg					3.8 U	4.1 U	3.9 U					
3-Nitroaniline	mg/kg					3.8 U	4.1 U	3.9 U					
4-Nitroaniline	mg/kg					3.8 U	4.1 U	3.9 U					
Nitrobenzene	mg/kg					0.81 U	0.86 U	0.83 U					
2-Nitrophenol	mg/kg					0.35 U	0.37 U	0.36 U					
4-Nitrophenol	mg/kg					1.8 U	2 U	1.9 U					
N-Nitrosodiphenylamine	mg/kg					0.81 U	0.86 U	0.83 U					
N-Nitrosodi-n-propylamine	mg/kg					0.81 U	0.86 U	0.83 U					
Pentachlorophenol	mg/kg					3.8 U	4.1 U	3.9 U					

TABLE 5.2 (Continued)  
SUMMARY OF SOIL ANALYTICAL DATA  
Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

Analyte	Units	Sample Location-Depth (ft bgs), Date, and Method											
		SB2-12 12/10/1998 VOCs	SB3-12 12/11/1998 VOCs	SB3R-12 2/2/1999 VOCs	SB4-12 12/11/1998 VOCs	SB2-12 2/2/1998 SVOCs	SB3-12 2/2/1998 SVOCs	SB4-12 2/2/1998 SVOCs	SB2-12 12/10/1998 VPH/EPH	SB4-12 12/11/1998 VPH/EPH	SB1-9 12/11/1998 TRPH	SB5-12 12/11/1998 TOC	SB6-12 12/11/1998 TOC
n-Propylbenzene	mg/kg	4.4 J	0.16 JI	0.0086	0.58 U	0.63 J	0.86 U	2.7					
Phenanthrene	mg/kg					0.35 U	0.37 U	0.36 U					
Phenol	mg/kg												
Pyrene	mg/kg					0.28 J	0.86 U	1.3					
Styrene	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
1,1,1,2-Tetrachloroethane	mg/kg	3.2 UJ	0.41 U	0.0092 U	0.87 U								
1,1,2,2-Tetrachloroethane	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
Tetrachloroethene	mg/kg	7.4 UJ	0.95 U	0.022 U	2 U								
1,2,3-Trichlorobenzene	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U								
1,2,4-Trichlorobenzene	mg/kg	2.1 UJ	0.27 U	0.0062 U	0.58 U	0.81 U	0.86 U	0.83 U					
1,1,1-Trichloroethane	mg/kg	4.2 UJ	0.54 U	0.012 U	1.2 U								
1,1,2-Trichloroethane	mg/kg	5.3 UJ	0.68 U	0.015 U	1.5 UJ								
Trichloroethene	mg/kg	11 UJ	1.4 U	0.031 U	2.9 U								
Trichlorofluoromethane	mg/kg	4.2 UJ	0.54 U	0.012 U	1.2 UJ								
1,2,3-Trichloropropane	mg/kg	21 UJ	2.7 U	0.062 U	5.8 UJ								
2,4,5-Trichlorophenol	mg/kg					3.8 U	4.1 U	3.9 U					
1,2,4-Trimethylbenzene	mg/kg	47 J	2.9	0.073	0.96 JI								
1,3,5-Trimethylbenzene	mg/kg	25 J	2.8	0.073	0.87 U								
Vinyl chloride	mg/kg	9.5 UJ	1.2 U	0.028 U	2.6 U								
2-Chloronaphthalene	mg/kg					0.81 U	0.86 U	0.83 U					
1,2-Dibromo-3-chloropropane	mg/kg	11 UJ	1.4 U	0.031 U	2.9 U								
1,2-Dibromoethane	mg/kg	3.2 UJ	0.41 U	0.0092 U	0.87 U								
Di-n-butyl phthalate	mg/kg					0.81 U	0.86 U	0.83 U					
4-Methylphenol	mg/kg					0.35 U	0.37 U	0.36 U					
2,4,6-Trichlorophenol	mg/kg					0.35 U	0.37 U	0.36 U					

Note: Shaded areas denote all detected concentrations.

\* mg/kg = Milligrams per kilogram.

\* UJ = The analyte was not detected above the practical quantitation limit (PQL). The value used may not be representative of the actual concentration.

\* U = The analyte was analyzed for and is not present above the reporting limit shown.

\* JI = This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.

\* --- = Not analyzed.

\* J = The analyte was positively identified, but the value may not be representative of what is actually present.

\* R = Analyte is rejected, presence of the analyte was not verified.

### 5.3 GROUNDWATER SAMPLING RESULTS

Groundwater sampling was performed as part of the recent risk-based investigation; analytical results are summarized in Table 5.3, and the distribution of total dissolved BTEX is depicted on Figure 5.1. Sample locations were selected based on the results of previous investigations and the objectives of this study. The sampling objectives were to determine the current areal extent and magnitude of fuel hydrocarbon concentrations in groundwater, and to obtain the appropriate chemical and geochemical data to document the occurrence and significance of biodegradation processes. As shown in Table 4.2, maximum concentrations of dissolved aliphatics (extractable petroleum hydrocarbons [EPH]) and aromatics (volatile petroleum hydrocarbons [VPH]) exceeded their respective Tier 1 screening levels (interim groundwater standards). The location of the exceedence was at well MP8-A (Figure 5.1). The state of North Carolina has not established GCLs for dissolved EPH and VPH. Only benzo(b)fluoranthene and benzo(k)fluoranthene at MP8-A exceeded their respective GCLs (Table 4.2). This well is located immediately downgradient from the former UST pit (Figure 5.1). The BTEX isoconcentration contours shown on Figure 5.1 incorporate the assumption that dissolved contamination migrates to the northeast from the vicinity of Well MW8-18 through the backfill surrounding the Tank Creek culvert. This backfill may represent a preferential migration pathway. The data suggest that the dissolved BTEX plume terminates prior to MP8-C, but it is not known if MP8-C intersects the backfill material that surrounds the culvert.

### 5.4 SURFACE WATER SAMPLING RESULTS

Two surface water samples were collected from Tank Creek, which traverses the site (Figure 5.1). One sample was collected approximately 300 feet southwest of (upstream from) the release location (immediately prior to entering the culvert), and the second sample was collected approximately 800 feet north of (downstream from) the release location, where the flow exits the culvert. Analytical results are summarized in Table 5.4. None of the aromatic VOCs targeted for analysis were detected.

**TABLE 5.3**  
**SUMMARY OF GROUNDWATER ANALYTICAL DATA**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Analyte	Units	Sample Location, Date, and Method																
		MP8-A 12/10/1998	MP8-B 12/10/1998	MP8-C 12/9/1998	MW8-8 12/9/1998	MW8-11 12/9/1998	SW1 12/11/1998	SW2 12/11/1998	MP8-A 12/10/1998	MP8-B 12/10/1998	MW8-8 12/9/1998	MP8-A 12/10/1998	MP8-B 12/10/1998	MW8-8 12/9/1998	MP8-B 12/10/1998	MW8-8 12/9/1998	MW8-11 12/9/1998	MW8-6 12/9/1998
		VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	
Benzene	µg/L <sup>w</sup>	27	4.2 J1 <sup>w</sup>	0.5 U <sup>w</sup>	0.82	30	0.5 U	0.5 U	0.5 U									
Ethylbenzene	µg/L	220	16 J <sup>w</sup>	0.5 U	3.6	13	0.5 U	0.5 U	0.5 U									
Toluene	µg/L	100	8.7 J	0.5 U	0.43 U	5 U	0.5 U	0.5 U	0.5 U									
Xylenes (total)	µg/L	950	61 J	0.24 U	2.9	44	0.5 U	0.5 U	0.5 U									
Aliphatics																		
C5-C8	µg/L	2,370																
C9-C18	µg/L	2,689																
C19-C36	µg/L	100U																
Aromatics																		
C9-C22	µg/L	2,022																
1,2,4-Trichlorobenzene	µg/L										10 U	10 U	10 U					
1,2-Dichlorobenzene	µg/L	12 U	6.9	0.5 U	0.5 U	5 U	0.5 U	0.5 U	0.5 U		10 U	10 U	10 U					
1,2-Diphenylhydrazine	µg/L										10 U	10 U	10 U					
1,3-Dichlorobenzene	µg/L	12 U	8	0.5 U	0.5 U	5 U	0.5 U	0.5 U	0.5 U		10 U	10 U	10 U					
1,4-Dichlorobenzene	µg/L	12 U	13 J	0.5 U	0.5 U	5 U	0.5 U	0.5 U	0.5 U		10 U	10 U	10 U					
2,4,6-Trichlorophenol	µg/L										10 U	10 U	10 U					
2,4-Dichlorophenol	µg/L										10 U	10 U	10 U					
2,4-Dimethylphenol	µg/L										4.1 J1	10 U	10 U					
2,4-Dinitrophenol	µg/L										50 U	50 U	50 U					
2,6-Dinitrotoluene	µg/L										10 U	10 U	10 U					
2-Chloronaphthalene	µg/L										10 U	10 U	10 U					
2-Chlorophenol	µg/L										10 U	10 U	10 U					
2-Nitrophenol	µg/L										10 U	10 U	10 U					
3,3'-Dichlorobenzidine	µg/L										50 R <sup>d</sup>	50 R	50 R					
4-Bromophenyl phenyl ether	µg/L										10 U	10 U	10 U					
4-Chloro-3-methylphenol	µg/L										10 U	10 U	10 U					
4-Chlorophenyl phenyl ether	µg/L										10 U	10 U	10 U					
4-Nitrophenol	µg/L										50 U	50 U	50 U					
Acenaphthene	µg/L										6.4 J1	10 U	1.6 J1	5 UJ <sup>w</sup>	5 UJ	1 R	1 U	
Acenaphthylene	µg/L										10 U	10 U	10 U	5 UJ	5 UJ	1 U	1 U	
Anthracene	µg/L										1.6 J1	1.1 J1	1.1 J1	3.5 J	1.1 J	0.1 U	0.43	
Benidine	µg/L										100 R	100 R	100 R					
Benzo(a)anthracene	µg/L										10 U	10 U	10 U	0.65 UJ	0.65 UJ	0.13 U	0.13 U	
Benzo(a)pyrene	µg/L										10 U	10 U	10 U	1.2 UJ	1.2 UJ	0.23 U	0.082 J1	
Benzo(b)fluoranthene	µg/L										10 U	10 U	10 U	0.9 UJ	0.9 UJ	0.18 U	0.21	
Benzo(g)luiperylene	µg/L										10 U	10 U	10 U	1 UJ	1 UJ	0.2 U	0.2 U	
Benzo(k)fluoranthene	µg/L										10 U	10 U	10 U	0.85 UJ	0.85 UJ	0.17 U	0.17 U	
bis(2-Chloroethoxy)methane	µg/L										10 U	10 U	10 U					
bis(2-Chloroethyl) ether	µg/L										10 U	10 U	10 U					
bis(2-Chloroisopropyl) ether	µg/L										10 U	10 U	10 U					
bis(2-Ethylhexyl) phthalate	µg/L										10 U	10 U	10 U					
Butyl benzyl phthalate	µg/L										10 U	10 U	10 U					
Chlorobenzene	µg/L	12 U	5.8	0.5 U	0.5 U	5 U	0.5 U	0.5 U	0.5 U		10 U	10 U	10 U	1 UJ	1 UJ	0.2 U	0.2 U	
Chrysene	µg/L										10 U	10 U	10 U					

TABLE 5.3 (Continued)  
SUMMARY OF GROUNDWATER ANALYTICAL DATA  
Risk-Based Approach to Remediation  
Site ST-08 (Building 41105)  
Pope AFB, North Carolina

Analyte	Units	Sample Location, Date, and Method															
		MP8-A 12/10/1998	MP8-B 12/10/1998	MP8-C 12/9/1998	MW8-8 12/9/1998	MW8-11 12/9/1998	SW1 12/11/1998	SW2 12/11/1998	MP8-A 12/10/1998	MP8-B 12/10/1998	MW8-8 12/9/1998	MP8-A 12/10/1998	MP8-B 12/10/1998	MW8-8 12/9/1998	MW8-11 12/9/1998	MW8-6 12/9/1998	MW8-9 12/9/1998
	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	VOCs	SVOCs	SVOCs	SVOCs	SVOCs	SVOCs	SVOCs	SVOCs	SVOCs	SVOCs	
Dibenzo(a,h)anthracene	µg/L																
Diethyl phthalate	µg/L							10 U	10 U								
Dimethyl phthalate	µg/L							10 U	10 U								
Di-n-butyl phthalate	µg/L							10 U	10 U								
Di-n-octyl phthalate	µg/L							10 U	10 U								
Fluoranthene	µg/L							1.9 J1	10 U								
Fluorene	µg/L							7.8 J1	10 U								
Hexachlorobenzene	µg/L							10 U	10 U								
Hexachlorobutadiene	µg/L							10 U	10 U								
Hexachlorocyclopentadiene	µg/L							50 R	50 R								
Hexachloroethane	µg/L							10 U	10 U								
Indeno(1,2,3-cd)pyrene	µg/L							10 U	10 U								
Isophorone	µg/L							10 U	10 U								
Methyl tert-butyl ether	µg/L	120 U	50 U	5 U	5 U	5 U											
Naphthalene	µg/L							140	110								
Nitrobenzene	µg/L							10 U	10 U								
N-Nitrosodimethylamine	µg/L							10 U	10 U								
N-Nitrosodi-n-propylamine	µg/L							1.5 J1	10 U								
N-Nitrosodiphenylamine	µg/L							10 U	10 U								
Pentachlorophenol	µg/L							50 U	50 U								
Phenanthrene	µg/L							11	7.6 J1								
Phenol	µg/L							10 U	10 U								
Pyrene	µg/L							1.5 J1	10 U								
					</												

Note: Shaded areas denote all detectable concentrations.

<sup>a</sup> µg/L = Micrograms per liter.

<sup>b</sup> J1 = This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.

<sup>c</sup> U = The analyte was analyzed for and is not present above the associated reporting limit shown.

<sup>d</sup> --- = Not analyzed.

<sup>e</sup> J = The analyte was positively identified, but the value may not be representative of what is actually present.

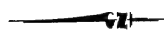
<sup>f</sup> mg/L = Milligrams per liter.

<sup>g</sup> R = Analyte is rejected, presence of the analyte was not verified.

<sup>h</sup> UJ = The analyte was not detected above the practical quantitation limit (PQL). The value used may not be representative of the actual concentration.

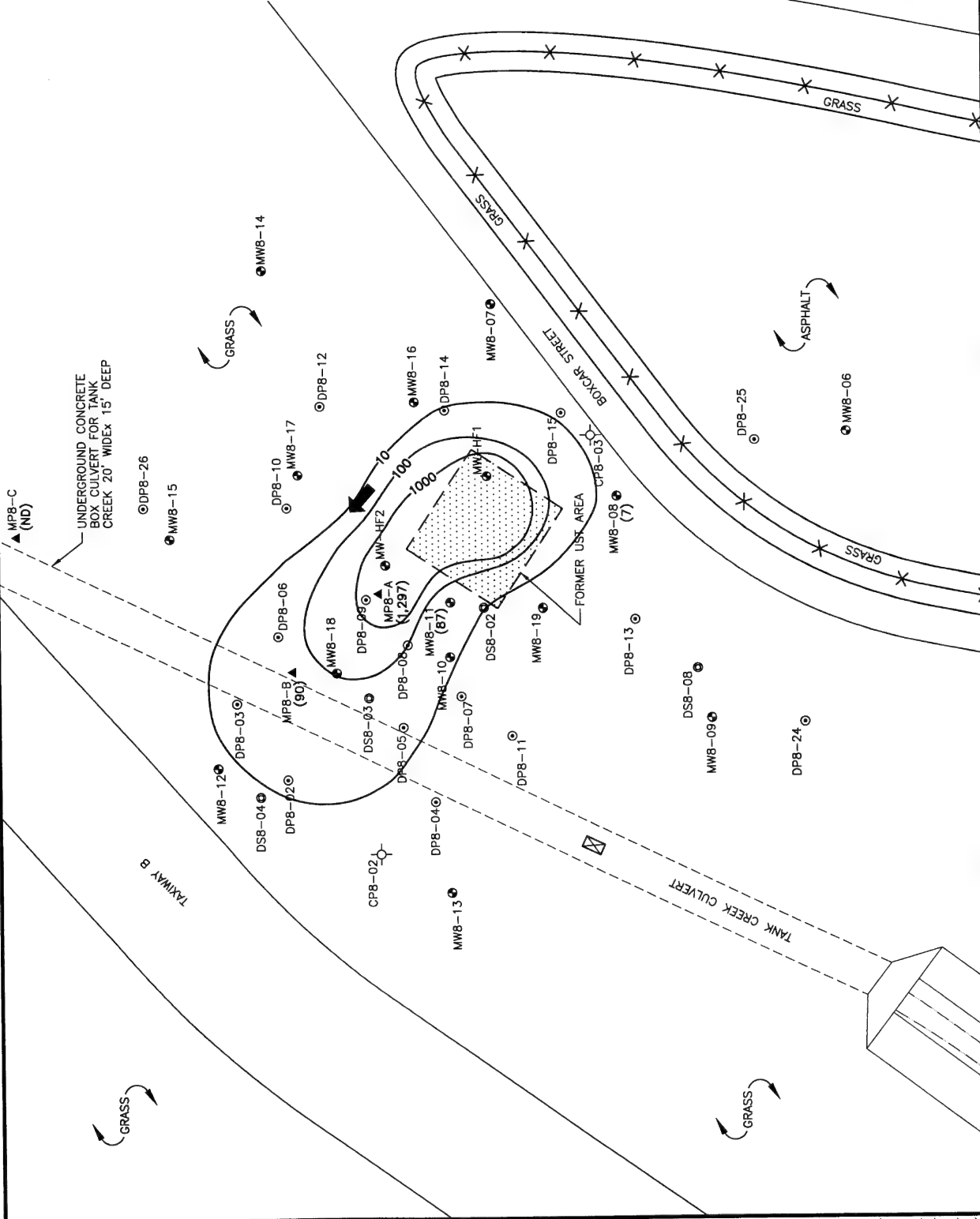
# LEGEND

- MPB-A ▲ GROUNDWATER MONITORING POINT INSTALLATION (TOTAL OF THREE, 1998)
- MWB-12 ● MONITORING WELL LOCATION
- DPB-10 ⊙ DIRECT PUSH GROUND WATER SAMPLE
- DSB-03 ⊕ DIRECT PUSH SOIL SAMPLE
- CPB-02 ⊖ CONE PENETROMETER TEST LOCATION
- EXCAVATED FORMER UST BASIN WITH OPERATING BIOVENTING SYSTEM
- GROUNDWATER FLOW DIRECTION
- STORM GRATE ENTRY POINT
- INFERRED LINE OF EQUAL BTEX CONCENTRATION (μg/L)
- ND NOT DETECTED
- (7) BTEX CONCENTRATION IN (μg/L)



**FIGURE 5.1**  
**DISSOLVED BTEX**  
**CONCENTRATIONS IN**  
**GROUNDWATER**  
**DECEMBER 1998**  
 Risk-Based Approach to Remediation  
 Site ST-08 (Building 41105)  
 Pope AFB, North Carolina

**PARSONS**  
**ENGINEERING SCIENCE, INC.**  
 Denver, Colorado



**TABLE 5.4**  
**SUMMARY OF SURFACE WATER ANALYTICAL DATA**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Analyte	Units <sup>a/</sup>	Sample Locations and Dates	
		SW1 12/4/1998	SW2 12/4/1998
Benzene	µg/L	0.5U <sup>b/</sup>	0.5U
Toluene	µg/L	0.5U	0.5U
Ethylbenzene	µg/L	0.5U	0.5U
Xylenes (total)	µg/L	0.5U	0.5U

a/ µg/L = micrograms per liter.

b/ U = the analyte was analyzed for and is not present above the associated reporting limit.

## **SECTION 6**

### **CHEMICAL FATE ASSESSMENT**

#### **6.1 INTRODUCTION**

Biodegradation of dissolved fuel constituents and the future migration and persistence of the dissolved contaminants identified in Section 4 are assessed in this section. As used throughout this report, the term "remediation by natural attenuation" (RNA) refers to a subsurface contaminant remediation strategy that relies on natural physical, chemical, and biological mechanisms to control exposure of potential receptors to concentrations of contaminants in soil and groundwater that exceed regulatory levels. These mechanisms include the processes of advection, hydrodynamic dispersion, dilution from recharge, sorption, volatilization, and biodegradation, which facilitate RNA of a variety of anthropogenic chemicals.

This section summarizes and interprets specific site characterization data relevant to documenting the effectiveness of RNA at minimizing dissolved contaminant migration and reducing contaminant concentration, mass, and toxicity over time. This assessment can be used to determine whether natural attenuation might be a useful component of a cost-effective remedial approach for the site.

#### **6.2 OPERATIVE MECHANISMS OF CONTAMINANT ATTENUATION**

Understanding the fate of COPCs in environmental media is critical to evaluating and predicting contaminant distribution patterns. There are several physical, chemical, and biological processes that influence how a chemical behaves in soil and groundwater. These processes must be evaluated when determining whether some type of remediation is warranted because chemical contamination poses or has the potential to pose a risk to human or ecological receptors. If contamination cannot reach a potential receptor exposure point, the contamination poses no risk.

Nondestructive attenuation processes can be described as those physical and chemical processes that may prohibit significant contaminant migration but will not result in a permanent reduction in contaminant mass. Examples of nondestructive attenuation processes include volatilization, sorption, dilution from recharge, advection, and hydrodynamic dispersion.

In comparison to nondestructive chemical attenuation processes, destructive chemical attenuation processes result in the permanent removal of contaminant mass from the environment. Documenting and distinguishing the effects of destructive attenuation processes, such as biodegradation, from nondestructive attenuation processes is critical to evaluating the potential for RNA to bring about a reduction in contaminant mass over



time. The effectiveness of destructive attenuation processes at reducing contaminant mass at a site depends on how susceptible the chemical is to biodegradation and whether the site is characterized by physical, chemical, and biological conditions favorable to such processes.

Numerous laboratory and field studies have shown that hydrocarbon-degrading bacteria can participate in the degradation of many of the chemical components of different types of fuels (e.g., heating oil) under both aerobic and anaerobic conditions. Biodegradation of fuel hydrocarbons will occur when an indigenous population of hydrocarbon-degrading microorganisms is present in the soil and groundwater, and sufficient concentrations of electron acceptors and nutrients, including fuel hydrocarbons, are available to these organisms. Soil and groundwater with a history of exposure to fuel hydrocarbon compounds, such as at Site ST-08, generally contain microbial populations capable of facilitating biodegradation reactions (Wiedemeier *et al.*, 1995). The chemical basis for the biodegradation of BTEX is described in more detail in Section 6.4, where geochemical data relevant to documenting biodegradation at the field scale at the site are presented.

### **6.3 EVIDENCE OF CONTAMINANT REDUCTION OVER TIME**

The first step in determining whether contaminant concentrations are being reduced in soil and groundwater at the site was to compare contaminant concentrations at selected sampling locations over time. The purpose of this comparison is to assess the evidence of field-scale contaminant mass loss. Decreases in the magnitude of contaminant concentrations at a site over time that cannot be explained by physical processes (e.g., source removal actions such as bioventing, mass transport in groundwater) may be the first indication that contaminants are biodegrading at the site.

#### **6.3.1 VOC Concentration Trends in Soil**

December 1998 soil contamination data was compared to historical soil contamination data to assess the effects of biodegradation. In 1995 and 1996, soil samples were collected at various locations as shown on Figure 2.1. The historical laboratory analytical data are compared in Table 6.1 to the analytical results for the December 1998 soil samples. In December 1998, soil sample SB1 was collected adjacent to previously sampled location PO1-MPA; both samples were analyzed for TRPH. The data indicate that soil concentrations at Site ST-08 have been substantially reduced since 1995 due to the combined effects of natural attenuation and bioventing.

#### **6.3.2 BTEX Concentration Trends in Groundwater**

Dissolved BTEX concentrations detected in samples from wells MW8-08 and MW8-11 in February 1997 and December 1998 also are compared in Table 6.1. The data indicate that groundwater BTEX concentrations at Site ST-08 have been reduced since 1997, most likely due to weathering of the source (free and residual product). This observation is consistent with the findings of a product weathering study conducted for the Air Force (Parsons ES, 1999). During this study, Parsons ES evaluated the natural weathering of light nonaqueous-phase liquids (LNAPLs) (free product) resulting from petroleum releases to the subsurface environment. The primary objective of this

**TABLE 6.1**  
**SUMMARY OF HISTORICAL COPC CONCENTRATIONS IN SOIL AND GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

**Soil**

Boring Location	Depth (ft bgs) <sup>a/</sup>	Date	Units	TRPH <sup>b/</sup>
PO1-MPA	9.5	Feb-95	mg/kg <sup>c/</sup>	4,160
SB1	9.5	Dec-98	mg/kg	11.2 UJ <sup>d/</sup>

**Groundwater**

Sample Location	Screened Interval (ft bgs)	Date	Units	BTEX <sup>e/</sup>
MW8-08	8'-18'	Feb-97	µg/L <sup>f/</sup>	27
MW8-08	8'-18'	Dec-98	µg/L	7
MW8-11	13'-23'	Feb-97	µg/L	273
MW8-11	13'-23'	Dec-98	µg/L	87

<sup>a/</sup> ft bgs = Feet below ground surface.

<sup>b/</sup> TRPH = Total recoverable petroleum hydrocarbons.

<sup>c/</sup> mg/kg = Milligrams per kilogram.

<sup>d/</sup> UJ = The analyte was not detected above the practical quantitation limit.

<sup>e/</sup> BTEX = Benzene, toluene, ethylbenzene, xylenes.

<sup>f/</sup> µg/L = Micrograms per liter.

AFCEE study was to document a range of BTEX weathering rates for free product based on data collected from sites with documented free product plumes with known release dates.

The weathering of BTEX from LNAPL via dissolution and volatilization is expected to follow first-order kinetics, which predicts that the rate of BTEX removal from the free-phase will be reduced as the concentrations of BTEX in the free-phase decrease over time. The average total first-order BTEX weathering rate for five JP-4 contaminated sites was approximately 16 percent per year, with a reasonable range of 11 to 23 percent per year. Compound-specific reduction rates were highest for benzene (the most soluble of the BTEX compounds), followed by toluene, xylenes, and ethylbenzene (the least soluble of the BTEX compounds). The average benzene first-order weathering rate for five JP-4 sites was approximately 26 percent per year, with a range of 19 to 35 percent per year. Although initial BTEX fractions in JP-8 are lower than JP-4 (as they are in heating oil), the first-order weathering rate for a JP-8 site at Seymour Johnson AFB, North Carolina was 25 percent per year for total BTEX and 29 percent per year for benzene.

### **6.3.3 Natural Attenuation Rates**

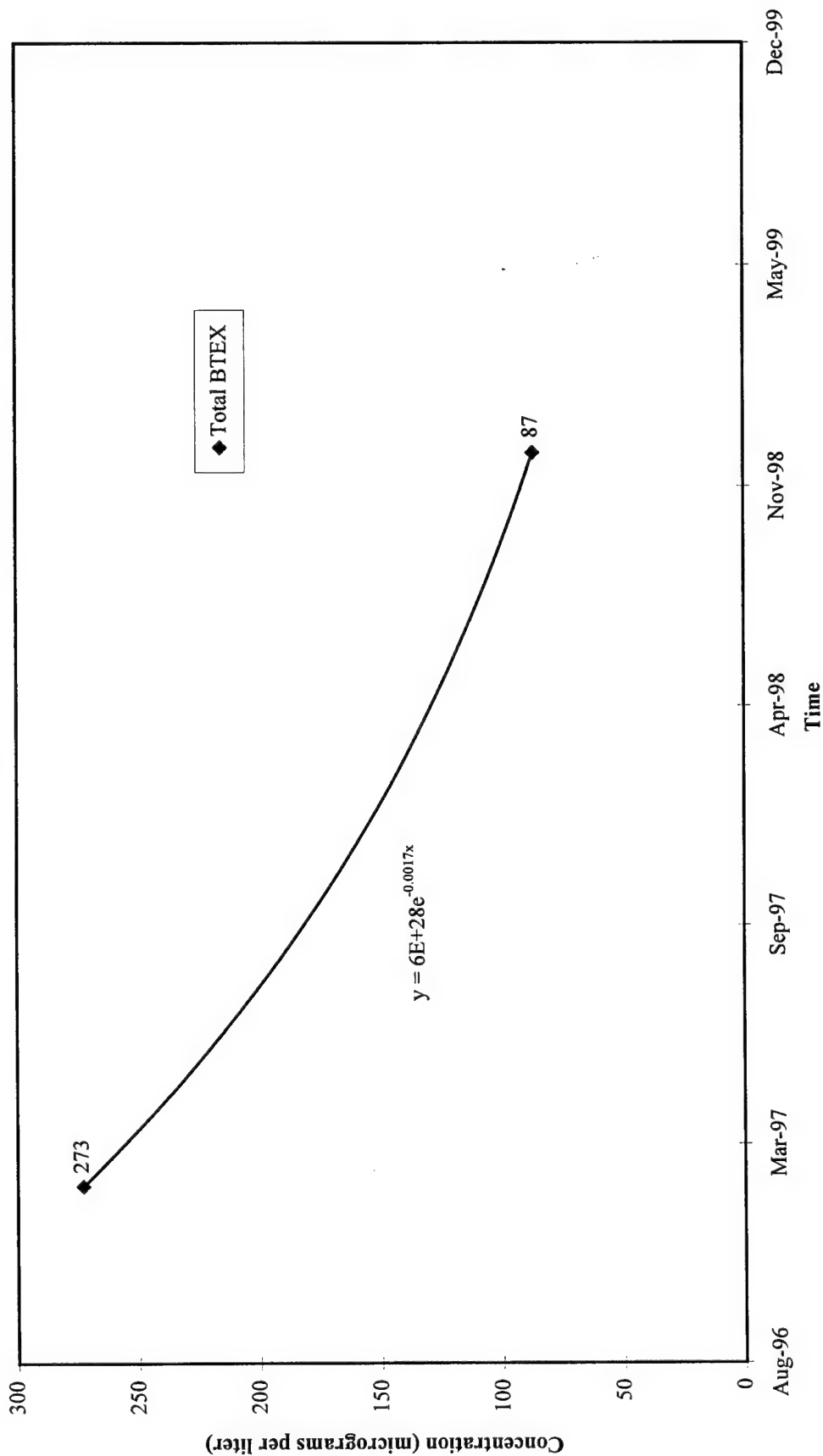
An exponential regression method can be used to derive destructive attenuation rates from concentration reduction data versus time (Buscheck and Alcantar, 1995). The reduction in contaminant concentrations at specific sampling points can be used to estimate a first-order attenuation rate, provided the plume size is relatively stable or decreasing. The stable plume method requires that groundwater analytical data for a minimum of two sampling stations (preferably at least three) are available. To the extent possible, the stations should be located within the plume along a line parallel to groundwater flow and contaminant migration, preferably along the longitudinal axis of the plume. In addition, the stations should be far enough apart that significant contaminant concentration changes due to the effects of biodegradation are evidenced from one station to the next.

The conditions described in the preceding paragraph are not fulfilled at Site ST-08 due to the presence of free product between the former UST pit and the Tank Creek culvert. Dissolved contaminants are added to the groundwater system along the plume flowpath, masking the effects of biodegradation. Therefore, a decay rate was not calculated using this method. In addition, use of the single-well method described for a shrinking plume by Buscheck and Alcantar (1995) would yield a decay rate that may be more representative of the source weathering rate than the rate of biodegradation of the dissolved constituent. Fitting an exponential, first-order, best-fit trend line to the BTEX data for well MW8-11 yields an attenuation rate of 0.0017 per day ( $\text{day}^{-1}$ ), which is equivalent to a half-life of 1.1 years (Figure 6.1).

## **6.4 EVIDENCE OF CONTAMINANT BIODEGRADATION VIA MICROBially MEDIATED REDOX REACTIONS**

Fuel hydrocarbons are typically utilized as electron donors in biologically mediated redox reactions under a wide range of geochemical conditions. Therefore, analytical data on potential electron acceptors can be used as geochemical indicators of fuel

**FIGURE 6.1**  
**DISSOLVED BTEX CONCENTRATIONS VS TIME AT MW8-11**  
 Risk-Based Approach to Remediation  
 Site ST-08 (Building 41105)  
 Pope AFB, North Carolina



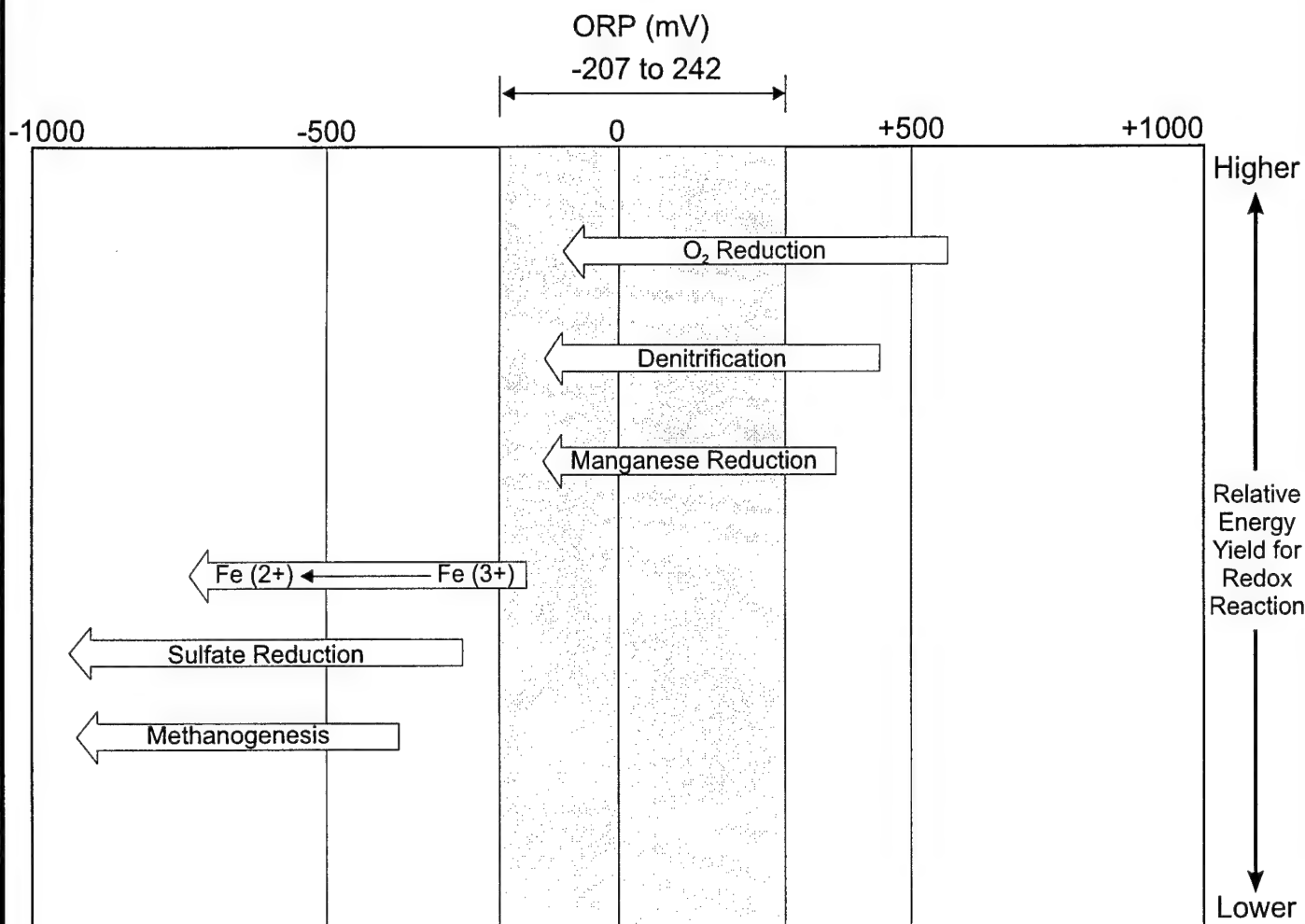
hydrocarbon biodegradation (Wiedemeier *et al.*, 1995). Reductions in the concentrations of oxidized chemical species that are used by microorganisms to facilitate the oxidation of fuel hydrocarbon compounds within contaminated media are an indication that contaminants are biodegrading. Alternately, an increase in the metabolic byproducts resulting from the reduction of electron acceptors can be used as an indicator of contaminant biodegradation. The availability of potential electron acceptors to participate in contaminant biodegradation reactions can be used to estimate the total contaminant mass that can be biodegraded over time at this site. This information can be used to predict how much dissolved COPC mass can be removed from saturated soil and groundwater at the site as a result of natural processes.

#### 6.4.1 Relevance of Redox Couples in Biodegradation

Microorganisms obtain energy to replenish enzymatic systems and to reproduce by oxidizing organic matter. Biodegradation of dissolved fuel hydrocarbons is the result of a series of redox reactions that maintain the charge balance within the natural environment. Microorganisms facilitate the degradation of these organic compounds by transferring electrons from the electron donor (i.e., fuel hydrocarbons and native organic carbon) to available electron acceptors. Electron acceptors are elements or compounds that occur in relatively oxidized states and can participate in redox reactions involving these available electron donors. Electron acceptors known to be present in saturated soil and groundwater at the site are oxygen, nitrate/nitrogen, sulfate, ferric iron, and carbon dioxide.

Microorganisms facilitate fuel hydrocarbon biodegradation to produce energy for their use. The amount of energy that can be released when a reaction occurs or is required to drive the reaction to completion is quantified by the free energy of the reaction (Stumm and Morgan, 1981). Microorganisms are able to utilize electron transport systems and chemiosmosis to combine energetically favorable and unfavorable reactions to produce energy for life processes (i.e., cell production and maintenance). Microorganisms will facilitate only those redox reactions that will yield energy. By coupling the oxidation of fuel hydrocarbon compounds, which requires energy, to the reduction of other compounds (e.g., oxygen, nitrate, manganese, ferric iron, sulfate, and carbon dioxide), which yields energy, the overall reaction will yield energy. Detailed information on the redox reactions required to biodegrade dissolved COPCs is included in Appendix D.

Figure 6.2 illustrates the sequence of microbially mediated redox processes based on the amount of free energy released for microbial use. In general, reactions yielding more energy tend to take precedence over processes that yield less energy (Stumm and Morgan, 1981). As Figure 6.2 shows, oxygen reduction would be expected to occur in an aerobic environment with microorganisms capable of aerobic respiration because oxygen reduction yields significant energy. However, once the available oxygen is depleted and anaerobic conditions dominate the interior regions of the contaminant plume, anaerobic microorganisms can utilize other electron acceptors in the following order of preference: nitrate, manganese, ferric iron, sulfate, and finally carbon dioxide. Each successive redox reaction provides less energy to the system, and each step down in redox energy yield would have to be paralleled by an ecological succession of microorganisms capable of facilitating the pertinent redox reactions.



### Notes

ORP = Oxidation Reduction Potential

 Range of ORP measured at Site ST-08

1. These reactions would be expected to occur in sequence if the system is moving toward equilibrium.
2. These redox processes occur in order of their energy-yielding potential (provided microorganisms are available to mediate a specific reaction). Reduction of a highly oxidized species decreases the ORP of the system.
3. The ORP of the system determines which electron acceptors are available for organic carbon oxidation.
4. Redox sequence is paralleled by an ecological succession of biological mediators.

FIGURE 6.2

### SEQUENCE OF MICROBIALY MEDIATED REDOX PROCESSES

Risk-Based Approach to Remediation

Site ST-08

Pope AFB, North Carolina

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Adapted from Stumm and Morgan, 1981 and Norris *et al.*, 1994.

The expected sequence of redox processes can be estimated by the ORP of the groundwater. The ORP measures the relative tendency of a solution or chemical reaction to accept or transfer electrons, and can be measured in the field. This measurement can be used as a crude indicator of which redox reactions may be operating at a site. High ORPs mean that the solution (or available redox couple) has a relatively high oxidizing potential.

Microorganisms can facilitate the biodegradation (oxidation) of the fuel hydrocarbon compounds only by using redox couples that have a higher ORP than the contaminants. This is why these electron acceptors can be used to oxidize the fuel hydrocarbon compounds. The reduction of highly oxidized species results in an overall decrease in the oxidizing potential of the groundwater. As shown in Figure 6.2, the reduction of oxygen and nitrate will reduce the oxidizing potential to levels at which ferric iron ( $\text{Fe}^{3+}$ ) reduction can occur. As each chemical species that can be used to oxidize the contaminants is exhausted, the microorganisms are forced to use other available electron acceptors with lower oxidizing capacity. When sufficiently low (negative) ORP levels have been developed as a result of these redox reactions, sulfate reduction and methanogenesis can occur almost simultaneously (Stumm and Morgan, 1981).

ORP values measured in shallow groundwater at the site in December 1998 ranged from -207 millivolts (mV) at MW8-11 to 242 mV at MW8-06 (Table 6.2). Areas with the lowest ORP measurements generally coincided with the presence of fuel-contaminated groundwater, indicating that the progressive use of electron acceptors in the order shown on Figure 6.2 has caused the groundwater in the contaminated areas to become more reducing. These data imply that oxygen, nitrate, manganese, and ferric iron may be used to biodegrade fuel hydrocarbon contaminants at this site. However, many authors have noted that field ORP data alone cannot be used to reliably predict all of the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some redox couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994). Analytical data on oxidized and reduced species are presented in the following subsections to verify which electron acceptors actually are being used to biodegrade fuel hydrocarbons in saturated soil and groundwater at the site.

Throughout the following subsections, the distributions of geochemical parameters are examined by comparing background concentrations to BTEX plume core concentrations. Analytical data from upgradient (MW8-06) and cross-gradient (MW8-09) wells are used for background concentrations. Analytical data from wells MW8-11, MP8-A and MP8-B are used for BTEX plume core concentrations.

#### 6.4.2 Dissolved Oxygen

Almost all types of fuel hydrocarbons can be biodegraded under aerobic conditions (Borden *et al.*, 1994). Mineralization of fuel hydrocarbons to carbon dioxide and water under aerobic conditions involves the use of oxygen as a cosubstrate during the initial stages of metabolism, and as a terminal electron acceptor during the later stages of metabolism for energy production. The reduction of molecular oxygen during the oxidation of the fuel hydrocarbon compounds yields a significant amount of free energy that the microorganisms could utilize.

**TABLE 6.2**  
**SUMMARY OF GROUNDWATER GEOCHEMICAL DATA**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Parameter	Units	Sample Location and Date <sup>a/</sup>						
		MW8-06 BG/UG 8-Dec-98	MW8-09 BG/CG 8-Dec-98	MW8-11 PL 8-Dec-98	MW8-08 BG/UG 8-Dec-98	MP8-C DG 9-Dec-98	MP8-B PL 9-Dec-98	MP8-A PL 10-Dec-98
Ferrous Iron	mg/L <sup>b/</sup>	0.0	0.0	3.95	4.40	2.0	7.45	5.75
Sulfate	mg/L	86	36.1	78.4	28.5	21.4	5.5	8.6
Nitrate	mg/L <sup>c/</sup>	2.4	2.5	1.0U <sup>d/</sup>	---	---	1.0 U	1.0 U
Methane	µg/L <sup>e/</sup>	0.13 U	1.5	3000	---	---	140	270
Temperature	Deg C <sup>f/</sup>	24.1	22.3	21.2 D <sup>g/</sup>	22.0	20.1	19.0	19.7
pH	SU <sup>h/</sup>	5.2	5.4	10.53 D	5.3	5.9	5.7	6.1
Conductivity	mS/cm <sup>i/</sup>	157	140	92 D	149	63	78	82
Dissolved Oxygen	mg/L	2.5	2.41	1.01 D	0.39	0.49	0.44	0.52
ORP <sup>j/</sup>	mV <sup>k/</sup>	242	218	-207	-147	-113	-177	-180
Alkalinity	mg/L	0 to 5	0 to 5	70	5 to 10	70	45	30
Ammonia	mg/L	0.0	0.0	<1.0	0.6	0.0	10.0	0.6

<sup>a/</sup> BG = Background; UG = Upgradient; CG = Cross-gradient; PL = Plume; DG = Downgradient.

<sup>b/</sup> mg/L = milligrams per liter.

<sup>c/</sup> U = The analyte was analyzed for and is not present above the reporting limit shown.

<sup>d/</sup> --- = Not analyzed.

<sup>e/</sup> µg/L = micrograms per liter.

<sup>f/</sup> Deg C = degrees Celsius.

<sup>g/</sup> D = Well went dry during purging.

<sup>h/</sup> SU = Standard Units.

<sup>i/</sup> mS/cm = microsiemens per centimeter.

<sup>j/</sup> ORP = Oxidation reduction potential.

<sup>k/</sup> mV = millivolts.



DO concentrations were measured at groundwater sampling locations in December 1998. Table 6.2 presents the analytical results for DO by sampling location. DO measured in groundwater from background wells ranged from 2.41 mg/L to 2.50 mg/L and averaged 2.45 mg/L. DO measured in contaminated groundwater in the plume core ranged from 0.44 mg/L to 1.01 mg/L and averaged 0.66 mg/L. As indicated in Table 6.2, well MW8-11 was purged dry, therefore, the DO value for this well may be artificially inflated due to the presence of bubbles in the pump tubing and/or cascading of water in the filter pack. If this DO value is not used, plume core DO concentrations ranged from 0.44 mg/L to 0.52 mg/L and averaged 0.48 mg/L. The presence of low DO concentrations in the most contaminated samples is an indication that biodegradation through aerobic respiration has occurred in this area.

#### 6.4.3 Nitrate and Ammonia

Once available DO concentrations are depleted through aerobic respiration, nitrate can be used as an electron acceptor by indigenous facultative anaerobes that mineralize fuel hydrocarbon compounds via either denitrification or nitrate reduction processes. Concentrations of nitrate measured at the site in December 1998 are summarized in Table 6.2. Nitrate measured in groundwater from background wells ranged from 2.4 mg/L to 2.5 mg/L. Nitrate was not detected in the plume core samples at a reporting limit of 1.0 mg/L. These data indicate that nitrate concentrations within the dissolved plume are depleted relative to measured background concentrations, and that nitrate is being used to oxidize fuel hydrocarbons in the anaerobic core of the dissolved plumes via the anaerobic process of denitrification.

The presence of ammonia in groundwater can result from either nitrate reduction (facilitated by microbes) or fixing of atmospheric nitrogen (also a microbial process). The presence of ammonia in groundwater is a strong indication of microbial activity.

Ammonia (as N) concentrations measured in groundwater samples collected in December 1998 are summarized in table 6.2. Ammonia concentrations detected in shallow groundwater varied across the site, with elevated ammonia concentrations occurring at monitoring point MP8-B in the BTEX plume area. Therefore, localized production of ammonia appears to be occurring due to increased microbial activity stimulated by the relative abundance of organic carbon (fuel hydrocarbons).

#### 6.4.4 Ferrous Iron

Although relatively little is known about the anaerobic metabolic pathways involving the reduction of ferric iron ( $\text{Fe}^{3+}$ ), this process has been shown to be a major metabolic pathway for some microorganisms (Lovley and Phillips, 1988; Chapelle, 1993). Elevated concentrations of ferrous iron ( $\text{Fe}^{2+}$ ) often are found in anaerobic, fuel-contaminated groundwater systems. Concentrations of dissolved ferrous iron once were attributed to the spontaneous and reversible reduction of ferric oxyhydroxides, which are thermodynamically unstable in the presence of organic compounds such as benzene. However, more recent studies suggest that the reduction of ferric iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993). None of the common organic compounds found in low-temperature, neutral, reducing groundwater could reduce ferric oxyhydroxides to ferrous iron under

sterile laboratory conditions (Lovley *et al.*, 1991). This means that the reduction of ferric iron to ferrous iron requires mediation by microorganisms with the appropriate enzymatic capabilities.

To determine if ferric iron is being used as an electron acceptor for fuel biodegradation at the site, ferrous (reduced) iron concentrations were measured at groundwater sampling locations in December 1998. The data are summarized in Table 6.2. Ferrous iron was not detected in groundwater from background wells. Conversely, ferrous iron measured in contaminated groundwater ranged from 3.95 mg/L to 7.45 mg/L and averaged 5.72 mg/L. The occurrence of elevated ferrous iron concentrations within the plume core strongly indicates that ferric iron is acting as an electron acceptor at this location and that fuel hydrocarbons are being biodegraded via the microbially-mediated process of ferric iron reduction.

#### **6.4.5 Sulfate**

Sulfate also may be used as an electron acceptor during microbial degradation of fuel hydrocarbons under anaerobic conditions (Grbic'-Galic', 1990). Sulfate can be reduced to sulfide during the oxidation of the fuel hydrocarbon compounds. The presence of decreased concentrations of sulfate in the source area relative to background concentrations indicates that sulfate is participating in redox reactions at the site. To investigate the potential for sulfate reduction at the site, sulfate concentrations were measured during the December 1998 groundwater-sampling event. The data are summarized in Table 6.2. Sulfate measured in groundwater from background wells ranged from 36.1 mg/L to 86 mg/L and averaged 61 mg/L. Sulfate measured in contaminated groundwater ranged from 5.5 mg/L to 78.4 mg/L and averaged 30.8 mg/L. With the exception of MW8-11, the occurrence of reduced sulfate concentrations within the plume core strongly indicates that sulfate is acting as an electron acceptor at this location and that fuel hydrocarbons are being biodegraded via the microbially-mediated process of sulfate reduction.

#### **6.4.6 Dissolved Methane**

On the basis of free energy yield and the oxidizing potential of the site groundwater, the carbon dioxide/methane ( $\text{CO}_2/\text{CH}_4$ ) redox couple also could be used to oxidize fuel hydrocarbon compounds to  $\text{CO}_2$  and water once the groundwater is sufficiently reducing. To attain these reducing levels, other highly oxidized chemical species such as oxygen, nitrate, ferric iron, and sulfate must first be reduced. This redox reaction is called methanogenesis or methane fermentation. Methanogenesis yields the least free energy to the system in comparison to other chemical species (Table 6.2). The presence of methane in groundwater at elevated concentrations relative to background concentrations is a good indicator of methane fermentation.

Dissolved methane was measured at groundwater monitoring wells sampled during the December 1998 sampling event. Table 6.2 presents the analytical data for methane. Methane concentrations measured in groundwater from background wells ranged from non-detect (less than 0.13  $\mu\text{g/L}$ ) to 1.5  $\mu\text{g/L}$  and averaged 0.78  $\mu\text{g/L}$ , (assuming that the non-detect concentration was equal to one-half the reporting limit of 0.13  $\mu\text{g/L}$ ). In contrast, methane concentrations measured in contaminated groundwater ranged from

140  $\mu\text{g/L}$  to 3000  $\mu\text{g/L}$  and averaged 1,137  $\mu\text{g/L}$ . The presence of elevated methane levels in groundwater at the site strongly indicates that biodegradation is occurring via methanogenesis.

#### **6.4.7 pH**

The pH of groundwater samples collected from groundwater monitoring points and monitoring wells in December 1998 was measured (Table 6.2). The pH of a solution is the negative logarithm of the hydrogen ion concentration  $[\text{H}^+]$ . Groundwater pH values measured at the site were slightly below the optimal range for fuel hydrocarbon-degrading microbes of 6 to 8 standard units (SUs); however, calibration of the pH meter was difficult to maintain due to a malfunctioning meter or probe. The pH of the majority of groundwater samples collected at the site ranged between 5.2 and 6.1 SUs.

#### **6.4.8 Temperature**

Groundwater temperature was measured at groundwater monitoring wells in December 1998 (Table 6.2). Temperature affects the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures generally resulting in higher growth rates. The temperature of groundwater samples collected from the shallow monitoring wells varied from 19.0 degrees Celsius ( $^{\circ}\text{C}$ ) to 24.1  $^{\circ}\text{C}$ . The relatively warm temperatures should promote microbial growth and may enhance rates of hydrocarbon biodegradation.

#### **6.4.9 Alkalinity**

Carbon dioxide is produced during the bioremediation of petroleum hydrocarbons. In aquifers that have carbonate minerals as part of the matrix, carbon dioxide forms carbonic acid, which dissolves these minerals, increasing the alkalinity of the groundwater. Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids.

An increase in alkalinity (measured as calcium carbonate  $[\text{CaCO}_3]$ ) in an area with BTEX concentrations elevated above background conditions can be used to infer the amount of petroleum hydrocarbon destroyed through aerobic respiration, denitrification, manganese reduction, ferric iron reduction, and sulfate reduction. Carbon dioxide produced in these aerobic and anaerobic reactions can be cycled in the methanogenic reactions to continue BTEX biodegradation through methanogenesis, but methanogenesis does not cause significant changes in alkalinity.

Total alkalinity at the site in December 1998 varied from less than or equal to 5 mg/L to 70 mg/L. As shown in Table 6.2, the highest alkalinity values occurred within and downgradient from the BTEX plume area. This is expected because the microbially mediated reactions causing biodegradation of fuel hydrocarbons produce carbon dioxide.

### **6.5 THEORETICAL ASSIMILATIVE CAPACITY ESTIMATES**

The preceding discussions have been devoted to determining if fuel hydrocarbons are biodegrading in saturated soil and groundwater at the site. Analytical data on reduced

and oxidized chemical species indicate that indigenous microorganisms are facilitating the oxidation of fuel hydrocarbons and the reduction of electron acceptors to generate free energy for cell maintenance and production. The question of how much contaminant mass can be biodegraded must be addressed to assess the full potential for long-term intrinsic bioremediation to minimize plume size and mass over time.

Mass balance relationships can be used to determine how much contaminant mass can be degraded by each of the redox reactions that the microorganisms might use to make free energy available for cell maintenance and production. The stoichiometric relationship between the contaminant and the electron acceptor can be used to estimate the expressed assimilative capacity of the groundwater. Once the redox reactions operating at the site have been defined, it is possible to estimate how much contaminant mass can be assimilated or oxidized by available electron acceptors.

The coupled redox reactions that represent the biodegradation of the individual COPCs, including the stoichiometric mass ratio of electron acceptors needed to oxidize each compound, are contained in Appendix D. These stoichiometric mass ratios can be used to estimate the assimilative capacity of the groundwater at Site ST-08. For oxygen, nitrate, and sulfate, this is accomplished by first determining the initial (background) mass of each electron acceptor available in the groundwater. Data on these chemical species were collected at sampling locations upgradient and cross-gradient from the dissolved plume. As groundwater slowly migrates into the source area, electron acceptors are brought into contact with hydrocarbon-degrading microorganisms and site contamination. The change in the electron acceptor mass from background sampling locations to sampling locations within the plume core is divided by the mass of electron acceptors required to mineralize the COPCs. For ferrous iron and methane, the average observed concentration in the plume core wells is divided by the mass of electron acceptors required to mineralize the COPC. These numbers are summed to estimate the expressed intrinsic capacity of the groundwater to biodegrade each COPC.

Estimates of the background and plume core concentrations were used to calculate the expressed assimilative capacity of the groundwater system attributable to aerobic respiration, denitrification, and sulfate reduction. The source area concentrations of ferrous iron and methane are used to "back-calculate" the expressed assimilative capacity that is attributable to ferric iron reduction and methanogenesis. The calculations are summarized in Table 6.3. This estimate essentially represents an estimate of the reduction capability of one pore volume of groundwater at Site ST-08. The estimate identifies how much contaminant mass can be theoretically oxidized as one pore volume travels through the plume core. In reality, multiple pore volumes are expected to move through the contaminated aquifer material in the source area each year based on an estimated groundwater velocity ranging from 120 ft/yr to 240 ft/yr (Section 3.2).

On the basis of these calculations, one pore volume of saturated soil and groundwater at Site ST-08 has the capacity to oxidize an average BTEX concentration of approximately 9,300  $\mu\text{g/L}$ . The maximum total BTEX concentration detected in site

**TABLE 6.3**  
**ESTIMATED ASSIMILATIVE CAPACITY OF SATURATED SOIL AND GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

<b>BENZENE</b>					
Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L) <sup>c/</sup>	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)	
Oxygen	2.5	0.48	3.07	0.66	
Nitrate	2.5	0.0	4.77	0.52	
Sulfate	61.1	30.83	4.61	6.57	
Ferrous Iron	0.0	5.72	21.5	0.27	
Methane	0.0008	1.14	0.77	1.48	
			Total	9.49	
			Max. 1998 Concentration (mg/L)	.03	

<b>TOLUENE</b>					
Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L) <sup>c/</sup>	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)	
Oxygen	2.5	0.48	3.13	0.65	
Nitrate	2.5	0.0	4.85	0.52	
Sulfate	61.1	30.83	4.7	6.44	
Ferrous Iron	0.0	5.72	21.86	0.26	
Methane	0.0008	1.14	0.78	1.46	
			Total	9.32	
			Max. 1998 Concentration (mg/L)	1.0	

**TABLE 6.3 (continued)**  
**ESTIMATED ASSIMILATIVE CAPACITY OF SATURATED SOIL AND GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

**ETHYLBENZENE**

Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L)	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)
Oxygen	2.5	0.48	3.17	0.64
Nitrate	2.5	0.0	4.92	0.51
Sulfate	61.1	30.83	4.75	6.37
Ferrous Iron	0.0	5.72	22	0.26
Methane	0.0008	1.14	0.79	1.44
			Total	9.22
			Max. 1998 Concentration (mg/L)	0.22

**XYLENES**

Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L)	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)
Oxygen	2.5	0.48	3.17	0.64
Nitrate	2.5	0.0	4.92	0.51
Sulfate	61.1	30.83	4.75	6.37
Ferrous Iron	0.0	5.72	22	0.26
Methane	0.0008	1.14	0.79	1.44
			Total	9.22
			Max. 1998 Concentration (mg/L)	1.0

**TABLE 6.3 (continued)**  
**ESTIMATED ASSIMILATIVE CAPACITY OF SATURATED SOIL AND GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

**NAPHTHALENE**

Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L) <sup>c/</sup>	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)
Oxygen	2.5	0.48	3	0.67
Nitrate	2.5	0.0	4.65	0.54
Sulfate	61.1	30.83	4.5	6.73
Ferrous Iron	0.0	5.72	40.13	0.14
Methane	0.0008	1.14	0.75	1.52
Total				9.60
Max. 1998 Concentration (mg/L)				0.2

**BENZO(b)FLUORANTHENE**

Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L) <sup>c/</sup>	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)
Oxygen	2.5	0.48	2.92	0.69
Nitrate	2.5	0.0	4.53	0.55
Sulfate	61.1	30.83	4.38	6.91
Ferrous Iron	0.0	5.72	39.06	0.15
Methane	0.0008	1.14	0.73	1.56
Total				9.86
Max. 1998 Concentration (mg/L)				0.001

**TABLE 6.3 (continued)**  
**ESTIMATED ASSIMILATIVE CAPACITY OF SATURATED SOIL AND GROUNDWATER**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

<b>BENZO(k)FLUORANTHENE</b>					
Electron Acceptor or Metabolic Byproduct	Background Concentration <sup>a/</sup> (mg/L) <sup>c/</sup>	Concentration in Core of Plume <sup>b/</sup> (mg/L)	Mass Ratio of Electron Acceptor/ Byproduct to COPCs <sup>d/</sup> (unitless)	Benzene Assimilative Capacity <sup>e/</sup> (mg/L)	
Oxygen	2.5	0.48	2.92	0.69	
Nitrate	2.5	0.0	4.53	0.55	
Sulfate	61.1	30.83	4.38	6.91	
Ferrous Iron	0.0	5.72	39.06	0.15	
Methane	0.0008	1.14	0.73	1.56	
			Total	9.86	
			Max. 1998 Concentration (mg/L)	2.3	

- <sup>a/</sup> Background concentrations were averaged from two background wells (MW8-06 and MW8-09).  
<sup>b/</sup> Concentrations in core of plume were averaged from the three plume wells (MP8-11, MP8-B, and MP8-A).  
<sup>c/</sup> mg/L = milligrams per liter.  
<sup>d/</sup> Calculation based on the ratio of the total mass of electron acceptor required to oxidize a given average of the mass of contaminants.  
<sup>e/</sup> Assimilative capacity is the amount of contaminant that can be degraded by a given process.



groundwater in December 1998 was 1,297  $\mu\text{g/L}$  at MP8-A. Therefore, the BTEX mass reduction capacity of the groundwater system at ST-08 is more than sufficient to oxidize the available contaminant mass dissolved in groundwater. Similarly, the mass reduction capacity for naphthalene, benzo(b)fluoranthene, and benzo(k)fluoranthene substantially exceeds the maximum detected concentrations of these compounds in site groundwater.

A closed system containing 2 liters of water can be used to help visualize the physical meaning of assimilative capacity. Assume that the first liter contains no fuel hydrocarbons, but it contains fuel-degrading microorganisms and has an assimilative capacity of exactly "x" mg of fuel hydrocarbons. The second liter has no assimilative capacity; however, it contains fuel hydrocarbons. As long as these 2 liters of water are kept separate, biodegradation of fuel hydrocarbons will not occur. If these 2 liters are combined in a closed system, biodegradation will commence and continue until the fuel hydrocarbons or electron acceptors are depleted. If less than "x" mg of fuel hydrocarbons are in the second liter, all of the fuel hydrocarbons will eventually degrade given a sufficient time; likewise, if greater than "x" mg of fuel hydrocarbons were in the second liter of water, only "x" mg of fuel hydrocarbons would ultimately degrade.

This example shows that in a closed system, the measured expressed assimilative capacity eventually should be equivalent to the loss in contaminant mass; however, the groundwater beneath the site is an open system. Electron acceptors can continually enter the system from upgradient flow. Furthermore, contaminant mass can be added to the system through dissolution or leaching from LNAPL or contaminated soil. This means that the assimilative capacity is not fixed as it would be in a closed system, and therefore should not be quantitatively compared to concentrations of dissolved contaminants in the groundwater. Rather, the expressed assimilative capacity of groundwater is intended to serve as a qualitative tool. The fate of BTEX in groundwater is dependent on the relationship between the kinetics of biodegradation and the solute transport velocities (Chapelle, 1994).

## **6.6 PREDICTING CONTAMINANT TRANSPORT AND FATE**

Understanding the effects of natural physical, chemical, and biological processes on chemicals in the subsurface is an important step in determining potential long-term risks associated with chemical migration in the environment. If destructive and nondestructive attenuation processes can minimize or eliminate the concentration of contaminants to which a receptor could be exposed, engineered remedial action may not be warranted either because no reasonable exposure pathway exists or because the exposure pathway would result in insignificant risks. The focus of this section is to predict how the migration of selected contaminants will be influenced by natural attenuation processes using site data and site-specific contaminant transport and fate models.

### **6.6.1 Fate and Transport of COPCs**

The two COPCs identified in Section 4, benzo(b)fluoranthene and benzo(k)fluoranthene, adsorb strongly to soils and do not easily leach to groundwater,

explaining the low magnitude of the concentrations detected in groundwater (less than or equal to 1 µg/L). Once in the groundwater, these compounds remain relatively immobile and should remain in the immediate vicinity of the source area. This observation is supported by the extremely high retardation coefficients calculated for these COPCs (Table 6.4). Aronson and Howard (1997) report that, in general, high molecular weight, multi-ring polynuclear aromatic hydrocarbons (PAHs) are thought to be resistant to anaerobic biodegradation in groundwater. These authors cite the results of a field study (Godsey *et al.*, 1992) where an anaerobic decay rate of 0.004 day<sup>-1</sup> was determined for acenaphthene in methanogenic groundwater. A biodegradation rate for acenaphthene of 0 (no degradation) to 0.004 day<sup>-1</sup> was derived by Aronson and Howard (1997). Therefore, although the migration potential of benzo(b)fluoranthene and benzo(k)fluoranthene is very limited, concentrations of these compounds may persist in groundwater.

## 6.6.2 Fate and Transport of BTEX

### 6.6.2.1 Migration of BTEX Without Biodegradation

In the absence of biodegradation, the BTEX migration rate can be approximated by dividing the seepage velocity ( $V_s$ ) by the retardation coefficient ( $R$ ).

#### Seepage Velocity ( $V_s$ )

Seepage velocity is the actual interstitial groundwater velocity. It is defined as the hydraulic conductivity ( $K$ ) times the hydraulic gradient ( $dH/dL$ ) divided by the effective porosity ( $n_e$ ).

$$V_s = (K/n_e)(dH/dL)$$

Seepage velocity was calculated in Section 3.2 to range approximately from 120 ft/yr to 240 ft/yr.

#### Retardation Coefficient ( $R$ )

The retardation coefficient is a measure of the degree of retardation of dissolved organic chemical movement through the aquifer. Retardation coefficients are calculated using the following formula:

$$R = 1 + (K_d p_b / n_t)$$

Where

$$K_d = (K_{oc})(f_{oc})$$

$K_{oc}$  = Organic Carbon Partition Coefficient

$f_{oc}$  = Fraction Organic Carbon

$p_b$  = Soil Bulk Density of Aquifer Matrix

$n_t$  = Total Porosity

An average retardation coefficient for the dissolved BTEX plume at Site ST-08 of 1.36 was calculated (Table 6.4).

**TABLE 6.4**  
**RETARDATION COEFFICIENTS OF SELECTED CONTAMINANTS**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Compound	K <sub>oc</sub> (L/kg <sup>a/</sup> )	Fraction Organic Carbon <sup>b/</sup>	Distribution Coefficient (L/kg)	Bulk Density (kg/L) <sup>c/</sup>	Total Porosity	Coefficient of Retardation
Benzene	79	0.000275	0.022	1.60	0.35	1.10
Toluene	190	0.000275	0.052	1.60	0.35	1.24
Ethylbenzene	468	0.000275	0.129	1.60	0.35	1.59
Xylenes	395	0.000275	0.109	1.60	0.35	1.50
Benzo(k)fluoranthene	549,540	0.000275	151.124	1.60	0.35	691.85
Benzo(b)fluoranthene	977,287	0.000275	268.754	1.60	0.35	1229.59

<sup>a/</sup> L/kg = liters per kilogram.

<sup>b/</sup> Because total organic carbon (TOC) concentrations were non detect (ND) at Site ST-08, half of the method detection limit (MDL) is used for this parameter.

<sup>c/</sup> kg/L = kilograms per liter.

## BTEX Migration

Using the values described above, the average BTEX migration distance in the absence of biodegradation should be approximately 88 to 176 feet per year. As described in Section 1.5, the fuel release occurred some time before the failed UST integrity test that was performed in 1992. If 1991 is conservatively assumed to be the release year, the calculated plume length in December 1998 should be approximately 600 to 1,680 feet if biodegradation was not occurring. As shown on Figure 5.1, the dissolved BTEX plume is estimated to have migrated approximately 140 feet downgradient from the former UST pit by December 1998. Furthermore, the data presented in Section 6.3 indicate that dissolved contaminant concentrations are decreasing over time. The decreasing concentrations combined with the disparity between the calculated plume length in the absence of biodegradation and measured site conditions support the conclusion that significant biodegradation of dissolved BTEX is occurring at Site ST-08.

### 6.6.2.2 BIOSCREEN MODELING

BIOSCREEN is a screening model which simulates the fate of dissolved hydrocarbons at petroleum fuel release sites (Newell *et al.*, 1996). The software is based on the Domenico (1987) analytical solute transport model and is designed to simulate advection, dispersion, adsorption, and aerobic decay as well as anaerobic reactions that have been shown to be the dominant biodegradation processes at many petroleum release sites. The BIOSCREEN modeling was performed for Site ST-08 primarily to estimate the maximum feasible migration distance of the dissolved BTEX plume over time, and to assess whether the dissolved BTEX plume could potentially impact downgradient receptors. BTEX was selected for simulation because these volatile compounds are relatively mobile compared to the higher molecular weight compounds present in #2 fuel oil, and therefore will have the greatest migration potential.

#### Description of BIOSCREEN Model

BIOSCREEN includes three different model types:

1. Solute transport without decay;
2. Solute transport with biodegradation modeled as a first-order decay process (simple, lumped parameter approach); and
3. Solute transport with biodegradation modeled as an "instantaneous" biodegradation reaction.

The first model is appropriate for predicting the movement of conservative (non-degrading) solutes such as chloride. The only attenuation mechanisms simulated are dispersion in the longitudinal, transverse, and vertical directions and adsorption of the chemical to the soil matrix. At almost all petroleum release sites, biodegradation is present and can be verified by demonstrating the consumption of aerobic and anaerobic electron acceptors. Therefore, results from the No Biodegradation model are intended

only to be used for comparison purposes and to demonstrate the effects of biodegradation on plume migration.

With the first-order model, the solute degradation rate is proportional to the initial solute concentration. This is a conventional method for simulating biodegradation in dissolved hydrocarbon plumes. With this method, dispersion, sorption, and biodegradation parameters are lumped together in a single calibration parameter (a first-order decay rate). The first-order model does not assume any biodegradation of dissolved constituents in the source zone, and therefore may underpredict the rate of decrease of source area contaminant concentrations. In other words, this model assumes that biodegradation starts immediately downgradient from the source and that it does not decrease the concentrations of dissolved organic compounds in the source zone itself. Because the available data are not sufficient to calculate a site-specific first-order decay coefficient with confidence, this model was not used to simulate plume migration at Site ST-08.

With the instantaneous reaction model, contaminant mass concentrations at any location and time within the flow field are corrected by subtracting 1 mg/L of organic mass for each mg/L of biodegradation capacity provided by all of the available electron acceptors, in accordance with the instantaneous reaction assumption. In other words, this model uses the assimilative capacity of the groundwater system to biodegrade contaminant mass.

### **Conceptual Model Design and Limiting Assumptions**

BIOSCREEN has the following limitations:

- As an analytical model, BIOSCREEN assumes simple groundwater flow conditions; and
- As a screening tool, BIOSCREEN only approximates the more complicated processes that occur in the field.

Because the model is not capable of simulating a complicated flow regime, the hydraulic input parameters for the site were based on the average values calculated or estimated using site-specific data and widely-accepted literature values.

### **Model Input Data**

Input data for the BIOSCREEN model are used to specify or calculate groundwater velocity, aquifer dispersivity, a retardation factor, a chemical-specific decay coefficient, dissolved hydrocarbon concentrations in the source area, a half-life of the hydrocarbon source, and the dimensions of the source zone. The parameters were obtained from site-specific data and commonly accepted literature values. The BIOSCREEN input screen is presented in Appendix E. Each of these input values is described in more detail below.

## Hydrogeology

**Seepage Velocity ( $V_s$ )** Seepage velocity is the actual interstitial groundwater velocity. It is defined as the hydraulic conductivity multiplied by the hydraulic gradient divided by the effective porosity. The  $V_s$  value used in the model is 180 ft/year (0.5 ft/day).

**Hydraulic Conductivity (K)** Hydraulic conductivity is a term that describes the relative ease with which water can move through a permeable medium. The horizontal K value used for shallow aquifer modeling, 3.3 ft/day, was derived as described in Section 3.2.

**Hydraulic Gradient (dH/dL)** The hydraulic gradient is a unitless value which represents the change in water table elevation per unit distance in a direction parallel to groundwater flow. The average hydraulic gradient at the site along the plume flowpath was calculated to be 0.03 ft/ft based on water table elevation data collected in December 1998.

**Effective Porosity ( $n_e$ )** The effective porosity of a medium is the ratio of the volume of interconnected voids to the bulk volume of the aquifer matrix. The effective porosity is typically less than total porosity because of non-interconnected pores, dead-end pores, and boundary effects of aquifer solids. An effective porosity of 0.20 (20 percent) was used in the model. This value is judged to be representative of average conditions within the shallow saturated zone based on the aquifer material and the average hydraulic conductivity.

## Dispersion

Dispersivity is a property of a porous medium that determines the dispersion or spreading characteristics of the medium by a relationship between pore-water velocity and dispersion coefficients. Published data summarized by Spitz and Moreno (1996) suggest that, as a rule of thumb, longitudinal dispersivity is approximately one-tenth the travel distance of the plume (from the source to the downgradient toe). The length of the BTEX plume downgradient from the source area is not known with precision; however, a longitudinal dispersivity of 20 feet was input into the model based on an estimated maximum plume length of 200 feet. The transverse dispersivity value is estimated as one-tenth of the longitudinal dispersivity value (Domenico and Schwartz, 1990), and vertical dispersivity is assumed to be negligible.

## Adsorption

**Retardation Factor** The retardation factor is a measure of the degree of retardation of dissolved organic chemical movement through the aquifer. An average retardation value of 1.36 was calculated for BTEX (Table 6.4).

**Organic Carbon Partition Coefficient ( $K_{oc}$ )** The organic carbon partition coefficient ( $K_{oc}$ ) is a chemical-specific partition coefficient between organic carbon and water (Newell *et al.*, 1996). The selected  $K_{oc}$  values for the BTEX compounds ranged

from 79 liters per kilogram (L/kg) for benzene to 468 L/kg for ethylbenzene (Weidemeier *et al.*, 1995).

**Fraction Organic Carbon ( $f_{oc}$ )** The fraction organic carbon ( $f_{oc}$ ) is the weight fraction of organic carbon in soil and is used in the estimation of the retardation factor. Typical  $f_{oc}$  values range from 0.0002 to 0.02 (Knox *et al.*, 1993). Total organic carbon was not detected in site soil samples; therefore, a TOC concentration equal to one-half the laboratory detection limit (550 mg/kg) was assumed to exist in site soil, which translates to a  $f_{oc}$  value of  $2.75 \times 10^{-4}$ .

**Soil Bulk Density ( $\rho_b$ )** The soil bulk density is the bulk density of the aquifer matrix and is related to the porosity and pure solids density. An estimated value of 1.6 kilograms per liter (kg/L) was used in this model (Newell *et al.*, 1996).

### Biodegradation

The Instantaneous Reaction Model was used for prediction purposes. According to Newell *et al.* (1996), a more accurate prediction of biodegradation effects may be realized by incorporating the instantaneous reaction equation into a transport model as opposed to a first-order decay coefficient.

Using field and laboratory analytical data, background concentrations from wells MW8-06 and MW8-09 and concentrations from plume wells MP8-A, MP8-B, and MW8-11 were used to calculate each of the electron acceptors/by-products listed below. Although BTEX compounds were detected at higher concentrations in site groundwater than most other fuel hydrocarbons, there are non-BTEX hydrocarbons that exert a demand on the available electron acceptors. Therefore, all available electron acceptor/by-product concentrations used in the model were reduced by 50 percent to account for the possible impacts of non-BTEX organics in groundwater. Newell *et al.* (1996) recommend a 30-percent reduction for conservative modeling of gasoline and JP-4 sites. A 50-percent reduction was used in this model due to the lower BTEX content of No. 2 fuel oil. Therefore, the delta for each of the indicators was reduced by 50 percent. This is potentially conservative because the relatively soluble BTEX compounds are present at higher concentrations in site groundwater than the higher molecular weight compounds, which are less soluble. BIOSCREEN calculates the biodegradation capacities (BCs) for individual parameters. The BC is the amount (in mg/L) of a parameter utilized to biodegrade 1 mg/L of hydrocarbon. The calculated differences are provided below.

#### Difference in DO

$$50\% [(Avg. Background Oxygen Conc.) - (Minimum Core Oxygen Conc.)]$$
$$Change in DO = 0.50 * (2.455 \text{ mg/L} - 0.44 \text{ mg/L}) = 1.0075 \text{ mg/L}$$

#### Difference in Nitrate

$$50\% \text{ of } [(Avg. Background Nitrate Conc.) - (Minimum Core Nitrate Conc.)]$$
$$Change in Nitrate = 0.50 * (2.45 \text{ mg/L} - 0.0 \text{ mg/L}) = 1.225 \text{ mg/L}$$



#### Difference in Ferrous Iron

50% of Avg. Core Ferrous Iron Conc.

$$\text{Ferrous Iron} = 0.50 * 5.72 \text{ mg/L} = 2.86 \text{ mg/L}$$

#### Difference in Sulfate

50% of [(Avg. Background Sulfate Conc.) - (Avg. Core Sulfate Conc.)]

$$\text{Change in Sulfate} = 0.50 * (61.05 \text{ mg/L} - 30.8 \text{ mg/L}) = 15.125 \text{ mg/L}$$

#### Difference in Methane

50% of Avg. Core Methane Conc.

$$\text{Methane} = 0.50 * 1.137 \text{ mg/L} = 0.5685 \text{ mg/L}$$

#### General

The modeled area length and width were set at 500 feet and 200 feet, respectively. The model was run for 20 years beyond 1998 for predictive purposes.

#### Source Data

**Source Thickness in Saturated Zone** The source thickness in the aquifer was input as 3 feet, based on an estimate of the thickness of the residual product smear zone below the water table.

**Source Area Dimensions and Concentrations** BIOSCREEN assumes a source represented by a vertical plane perpendicular to groundwater flow. This vertical plane was estimated using the dissolved benzene plume dimensions and concentrations in December 1998.

**Source Half-Life** BIOSCREEN incorporates an approximation for a declining source concentration over time. However, an infinite (continuous, non-degrading) source was simulated due to the presence of free product at the site.

**Source Mass.** Due to the presence of free product at the site, which constitutes a continuing source of BTEX to the groundwater, an infinite source mass was assumed for modeling purposes.

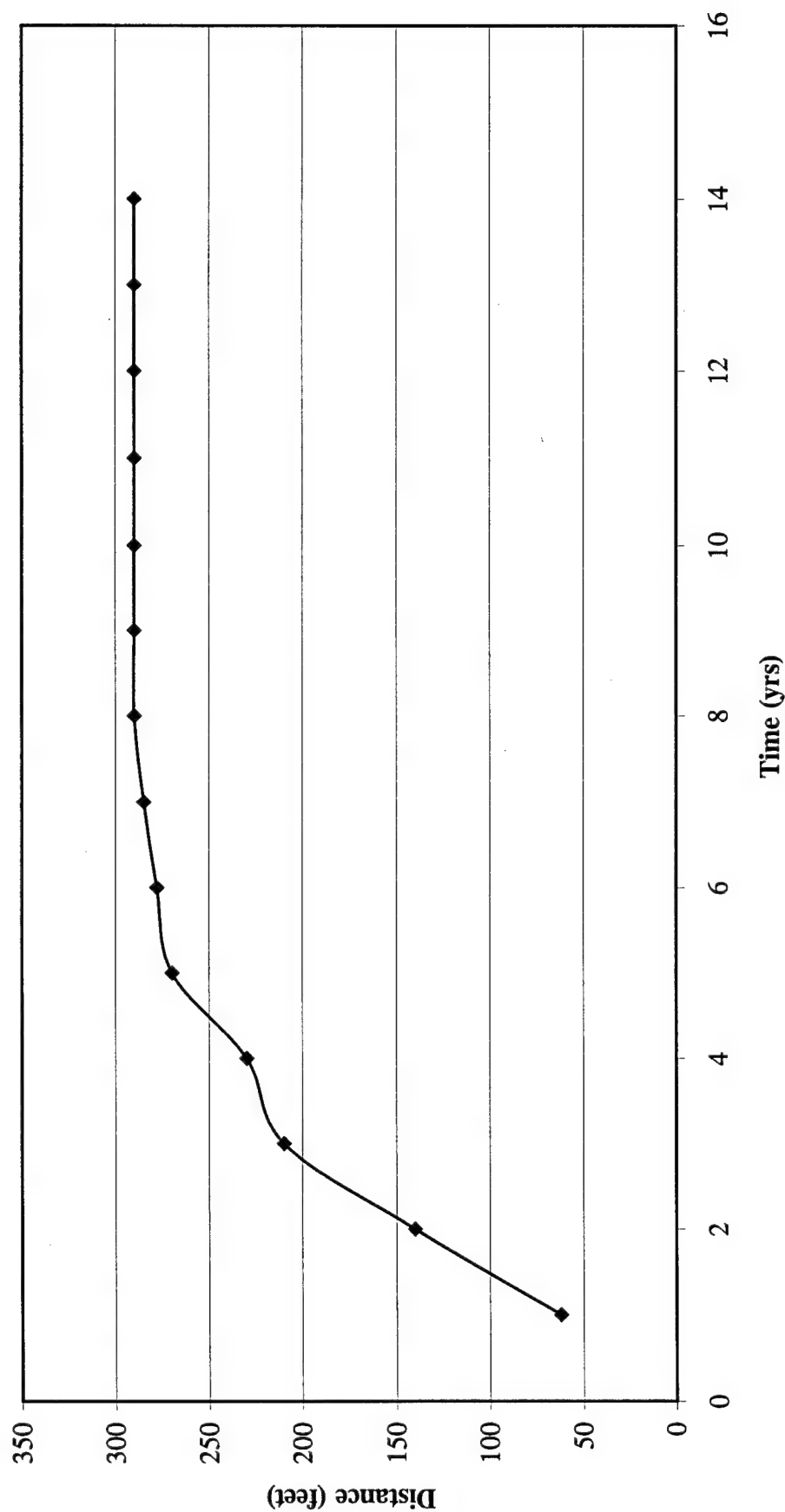
#### Model Calibration and Results

Typically, concentrations of dissolved contaminants begin to decrease as they migrate away from the source zone due to the effects of natural attenuation. In these cases, the BIOSCREEN model can be calibrated to simulate the measured concentration decreases. At Site ST-08 however, the free product plume (a continuous source) appears to extend from the former UST pit to the Tank Creek culvert, making calibration infeasible. Therefore, the model was not calibrated. Instead, the model was used to simulate the downgradient migration of the BTEX concentration detected at MP8-A (1,297  $\mu\text{g/L}$ ), assuming that this is the maximum BTEX concentration present in site groundwater.



The maximum predicted migration distance of the dissolved BTEX plume is shown on Figure 6.3. The Instantaneous Reaction Model predicts that the dissolved BTEX plume will migrate to its maximum distance of approximately 290 feet from the source area after approximately 8 years, after which it will achieve a steady state condition that lasts indefinitely due to the simulated constant source. Similar results are obtained if the simulated groundwater velocity is increased by an order of magnitude to 1,800 feet per year to model potentially more rapid plume migration through the backfill surrounding the Tank Creek culvert. In this case, the steady-state plume length is approximately 300 feet, and steady-state conditions are achieved more rapidly. This information suggests that the plume is at or near steady state. The nearest downgradient receptor is the open ditch approximately 900 feet north of the site. Therefore, the model predicts that the BTEX plume will not reach any downgradient receptors. The conclusion that dissolved fuel constituents will not impact downgradient receptors is supported by data presented by Lawrence Livermore National Laboratories (LLNL). These data indicate that for over 1,000 California sites with fuel hydrocarbon releases, 33 percent of the plumes were shrinking, 59 percent were stable, and 8 percent were expanding, with most plumes less than 250 feet long (Rice *et al.*, 1995). Unpublished data provided by Kuehne and Buscheck (1996) indicate similar trends, with 52 percent of plumes contracting, 35 percent stable, and 92 percent of the plumes being less than 200 feet long. Mace *et al.* (1997) present similar evidence for more than 600 sites in Texas.

**FIGURE 6.3**  
**MAXIMUM SIMULATED MIGRATION DISTANCE OF DISSOLVED BTEX OVER TIME**  
 Risk-Based Approach to Remediation  
 Site ST-08 (Building 41105)  
 Pope AFB, North Carolina



## SECTION 7

### TIER 2 ANALYSIS AND IDENTIFICATION OF FINAL CHEMICALS OF CONCERN

#### 7.1 OBJECTIVE OF SITE-SPECIFIC EVALUATION

The Tier 1 analysis conducted in this CAP (Section 4) identified benzo(b)fluoranthene and benzo(k)fluoranthene as COPCs in groundwater at Site ST-08. In this section, COPCs in groundwater are evaluated in detail to better define/assess the potential adverse health effects they may cause in current or future human receptors. Maximum detected contaminant concentrations in soil and surface water did not exceed their respective Tier 1 screening levels; therefore, further analysis of these matrices is not necessary. Although VPH and EPH carbon fractions exceeded their Tier 1 screening levels (interim groundwater standards reported in NCDEHNR [1998a]), the interim groundwater standards assume unrestricted groundwater use (e.g., use as a potable drinking water supply), and are therefore not applicable for this industrial site. The Tier 2 analysis developed in this section focuses on groundwater.

The Tier 1 screening process is considered protective of human health because the Tier 1 risk-based screening criteria are based on conservative exposure assumptions. However, analytes identified as COPCs in Section 4 of this CAP (i.e., analytes with representative site concentrations exceeding Tier 1 TCLs) should not automatically be considered to be present at the site at levels that pose unacceptable threats to human health given the current and future exposure potential at this site. Rather, the exceedences of the conservative screening criteria indicate that further evaluation using more site-specific exposure scenarios is warranted. The presence of various analytes at concentrations above the applicable generic Tier 1 screening levels also justifies the need for a Tier 2 evaluation to assist in the development of corrective actions that can achieve the desired level of risk reduction at the site.

Tier 2 of the risk-based analysis is completed in Section 7.2 by comparing appropriate site groundwater concentrations (December 1998) to reasonable matrix-specific site-specific target levels (SSTLs) at receptor exposure points. These SSTLs are described as the Tier 2 risk-based screening criteria and may differ from the generic Tier 1 screening levels in terms of exposure assumptions. The SSTLs incorporate realistic site-specific exposure assumptions that are based on projected land uses.

Development of site-specific exposure scenarios requires a reevaluation of the preliminary CSM presented in Section 4. The revised CSM for the site, which is presented in Section 7.3, identifies those receptors and exposure pathways that may be completed under current or hypothetical future exposure scenarios considering land

uses and the results of the chemical fate and transport assessment presented in Section 6.

In summary, the objectives of developing SSTLs that include exposure assumptions more representative of actual site conditions are 1) to determine whether current or predicted future site concentrations of COPCs present an unacceptable risk to current and future receptors; and 2) to provide the necessary information to assess the cost and time required to lower site concentrations to achieve adequate risk reduction at the site.

## **7.2 DEVELOPMENT OF SITE-SPECIFIC TARGET LEVELS**

### **7.2.1 Tier 2 Analysis for Groundwater**

The COPCs in groundwater at Site ST-08 were screened against groundwater SSTLs developed using guidelines set forth in ASTM (1995) and USEPA (1989, 1991, 1993, and 1997). A USEPA recommended target risk limit of  $1 \times 10^{-6}$  was used in developing the Tier 2 SSTLs. The intrusive construction worker exposure assumptions used to derive the SSTLs were based on actual studies of construction-related exposures at Eglin AFB, Florida, and have been reviewed and accepted by the State of Florida.

Table 7.1 presents the chemical-specific groundwater SSTLs for Site ST-08. Note that two sets of SSTLs are presented; a reasonable maximum exposure (RME) and a central tendency (CT). The RME SSTLs are designed to illustrate the residual concentration that can persist in onsite groundwater given "high-end" (reasonable maximum) exposure potential, whereas the CT SSTLs better illustrate the residual concentration that can persist in onsite groundwater given mean or average exposure potential. The CT SSTLs are presented for comparative purposes only to provide a less-than-maximum-exposure perspective.

The groundwater SSTLs are health-based values calculated to protect onsite intrusive workers from health risks associated with exposure to chemical contamination in groundwater. The generic health-based Tier 1 screening levels (GCLs) are calculated assuming one of three conditions: 50 percent of the solubility at 25 degrees Celsius; 1000 times the federal drinking water standard (40 CFR 141); or 1000 times the North Carolina groundwater standard (15A NCAC 2L .0202). The exposure pathways incorporated into the groundwater SSTLs include dermal contact, incidental ingestion of groundwater, and vapor inhalation including inhalation of volatilized contaminants in aboveground ambient air (75 percent of the exposure frequency) and in an excavated trench (25 percent of the exposure frequency). SSTL calculations are contained in Appendix D. It should be noted that the average groundwater depth appears to be near or below the maximum excavation depth for a construction scenario (12 feet). Therefore, dermal contact with and incidental ingestion of groundwater could only occur during high water periods when the water table is shallower than 12 feet bgs.

As shown in Table 7.1, COPC concentrations in groundwater at Site ST-08 do not exceed their respective SSTLs. The lack of SSTL exceedences indicates that concentrations of benzo(b)fluoranthene and benzo(k)fluoranthene do not pose a significant health risk to intrusive construction workers. This comparison is

**TABLE 7.1**  
**COMPARISON OF MAXIMUM GROUNDWATER DETECTIONS TO SITE-SPECIFIC TARGET LEVELS (SSTLs)**  
**Risk-Based Approach to Remediation**  
**Site ST-08 (Building 41105)**  
**Pope AFB, North Carolina**

Chemical of Potential Concern	Units	Maximum Detected Concentration	Tier 2 Health-Based SSTL CT <sup>a/</sup>	RME <sup>b/</sup>	Maximum Detection Exceeds SSTL
Benzo(b) fluoranthene	µg/L <sup>c/</sup>	1 J <sup>d/</sup>	34.7	4.39	No
Benzo(k) fluoranthene	µg/L	0.7 J	347	43.9	No

<sup>a/</sup> CT = central tendency.  
<sup>b/</sup> RME = reasonable maximum exposure.  
<sup>c/</sup> µg/L = micrograms per liter.  
<sup>d/</sup> This is an estimated result. The analyte was positively identified and has a concentration between the method detection limit and the reporting limit.

conservative in that available data indicate that contaminant concentrations in the subsurface are decreasing due to weathering processes (Section 6.3)

### **7.3 REVISED CONCEPTUAL SITE MODEL**

The preliminary CSM presented in Section 4 was used to qualitatively identify potential human and ecological receptors that may be exposed to site-related contaminants and to define the types of potential exposures at or in the vicinity of Site ST-08 (Figure 4.1). The preliminary CSM described sources of contamination, release mechanisms, the affected physical media, potentially exposed populations or receptors, and how each receptor group could come into contact with site-related contamination. This preliminary CSM was used to identify which of the exposure assumptions used to develop generic cleanup criteria most closely approximates site conditions. The exposure assumptions incorporated into the generic Tier 1 screening levels were identified as generally representative of the types of exposure that could occur at the site, but perhaps overestimated the magnitude of exposure specific to current and expected future site conditions. The preliminary CSM exposure pathways are reevaluated in this section using the Tier 2 chemical fate information presented in Sections 6 and 7.2. It is important to emphasize that the purpose of using the preliminary CSM and the conservative, nonsite-specific Tier 1 screening levels to identify COPCs was to ensure that all subsequent assessment activities beyond the Tier 1 screening evaluation address the full range of contaminants that may present some risk to current or future receptors.

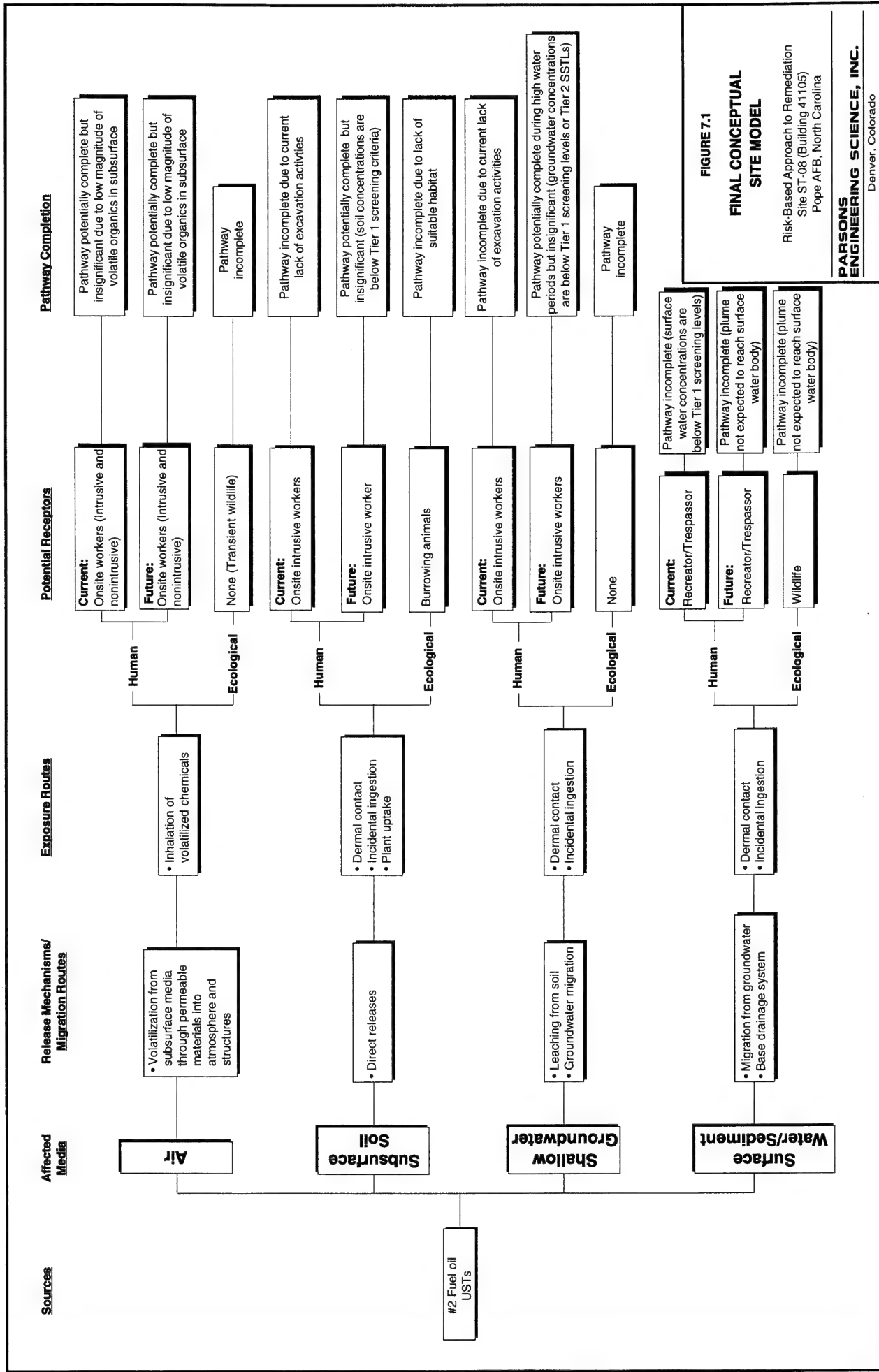
The revised CSM for the site, which is presented on Figure 7.1 and briefly reviewed in the following subsections, identifies those receptors and exposure pathways that realistically may be involved in actual current or hypothetical future exposures. The outcome of the Tier 2 evaluation of site COPCs presented in Section 7.2, and the types of exposures likely to occur at this industrial site, are reflected in this revised CSM. Justification for each site-specific exposure assumption is provided in subsequent discussions.

#### **7.3.1 Sources, Release Mechanisms, and Affected Media**

Contamination at the site is present as a result of leaking UST(s) at the site. The USTs were removed; therefore, direct release is currently not a potential release mechanism. Free product is currently present at the site, and there is no free product recovery system in use at this time. Data indicate that the predominant ongoing release mechanism for groundwater contamination is partitioning from free and residual product.

#### **7.3.2 Potentially Exposed Receptors, Exposure Points, and Exposure Routes**

The revised CSM for the site also refines the identification of potentially exposed receptor populations, receptor exposure points, and exposure routes for realistic scenarios based on specific site conditions. These components better reflect the likelihood and extent of human or ecological receptor contact with site-related contaminants. As described in Section 2, the site is entirely within the boundaries of



the Base. Therefore, potential receptors are limited to the on-Base population. There are no completed pathways to off-Base receptors.

Information resulting from this study indicates that none of the current or potential future exposure pathways that are or potentially could be completed are of significance. The concentrations of volatile constituents in No. 2 fuel oil are relatively low; therefore the contamination does not pose a significant inhalation risk to aboveground receptors. Soil contaminant concentrations are below Tier 1 screening levels, and those constituents in groundwater that exceeded Tier 1 GCLs were below Tier 2 SSTLs. In addition, the dissolved plume is not expected to migrate to a downgradient receptor (e.g., the open Tank Creek channel).

#### 7.4 SUMMARY AND CONCLUSIONS

The following conclusions can be drawn:

- Concentrations of target analytes in soil and surface water samples did not exceed applicable health-protective Tier 1 screening levels; therefore, site soil and surface water contamination does not pose a significant risk to potential receptors under reasonable current and future land use scenarios.
- Dissolved concentrations of two PAHs in groundwater slightly exceeded Tier 1 screening levels, but did not exceed applicable health-protective Tier II SSTLs. Although VPH and EPH levels exceeded the interim groundwater standards, these standards are not applicable for this industrial site. In addition, the results of BIOSCREEN modeling indicate that dissolved contaminants will not impact downgradient receptors. Therefore, site groundwater contamination does not pose a significant risk to potential receptors under reasonable current and future land use scenarios.
- Contaminant and geochemical data strongly indicate that biodegradation of fuel hydrocarbons is occurring at the site, primarily via the anaerobic processes of sulfate reduction and methanogenesis. In addition, the BTEX content of the free product is being reduced over time via weathering.
- Pope AFB is an active Base where institutional controls such as land use restrictions can be maintained with a high level of confidence.
- None of the current or future potential exposure pathways described in Section 4.2 are considered to be significant.
- Based on the criteria listed in Section 1.3, Site ST-08 would be classified as an intermediate risk site due to the presence of free product. However, available data support the conclusion that the site does not pose a significant risk to potential receptors as long as direct contact with free product is avoided during intrusive activities, land use remains commercial/industrial, and exposures are limited to the types evaluated in this report (e.g., intrusive construction worker). Removal of recoverable free product would substantially reduce the persistence of contaminants dissolved in groundwater at the site.



## SECTION 8

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**APPENDIX A**  
**LABORATORY ANALYTICAL DATA**

Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

## ANALYTICAL REPORT

Pope AFB  
Lot #: D8L100136

John Hicks  
Parsons Engineering Services

QUANTERRA INCORPORATED

  
Ellen La Riviere  
Project Manager

January 21, 1999

# Table Of Contents

## Standard Deliverables With Supporting Documentation

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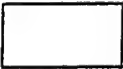
A.	<b>Standard Deliverables</b>	78
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- Executive Summary – Detection
- Analytical Methods Summary
- Method/Analyst Summary
- Lot Sample Summary
- Analytical Results by Sample
- QC Data Association Summary
- Chain-of-Custody

### Supporting Documentation

[Please Note: A one-page "Description of Supporting Documentation" is provided in the Supporting Documentation section(s).]

B.	• Volatile GC/MS	
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C.	• Semivolatile GC/MS	
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D.	• Volatile GC	
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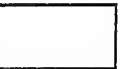
E.	• Semivolatile GC	
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F.	• LC/MS or HPLC	
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G.	• Metals	
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H.	• General Chemistry	
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I.	• Subcontracted Data	
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Total # Pages in this Package		
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# Project Narrative

(D8L100136)

## GC/MS Semi-Volatiles

The extraction lab ran out of all analyte spike, and it was not possible to obtain a new supply prior to sample expiration. Therefore, an expired all analyte spike standard (V11292) was used to prepare the LCS/LCSD and MS/MSD for QC Batch 8344205. The expired standard was re-verified, but the re-verification showed that benzidine and 3,3'-dichlorobenzidine had degraded and were no longer present in the expired standard.

The MS is the primary control sample for method 625. The LCS is used as a backup for the MS.

As expected, the recoveries of benzidine and 3,3'-dichlorobenzidine were out of control in the MS/MSD associated with sample D8L100136-001. The LCS/LCSD associated with this sample was also out-of-control for benzidine and 3,3'-dichlorobenzidine. Since it can be shown that these compounds were out-of-control because the spiking standard had degraded, no corrective action was taken.

The relative percent differences for 1,2-diphenylhydrazine, hexachlorocyclopentadiene and N-nitrosodiphenylamine also exceeded the control limits in the LCS/LCSD associated with the Method 625 batch 8344205. Because these compounds were within acceptable limits in the MS/MSD, no further action was required by the Method.

The MS/MSD associated with D8L100136-001 had a high RPD for hexachlorocyclopentadiene. No corrective action was taken for this problem because hexachlorocyclopentadiene is not a control analyte for this method and there is no RPD control criteria listed. The LCS/LCSD associated with this sample was also out of control for hexachlorocyclopentadiene. This problem was not related to the use of an expired spiking standard.

## Polynuclear Aromatic Hydrocarbons

Dibenzo(a,h)anthracene was recovered above the upper control limits in the LCS/LCSD associated with the sample in this project. Because this would indicate a high bias to the data, and this compound was not detected in the samples, no further action was required.

## Methane by RSK-175

The methane analysis by RSK-175 was performed by Quanterra's laboratory located in Austin, Texas.

Sample D8L100136-004 was originally analyzed undiluted. Methane was detected at a concentration above the linear calibration range of the instrument and has been reported with an "E flag." The sample was reanalyzed at the appropriate dilution. Both sets of data have been reported.

# EXECUTIVE SUMMARY - Detection Highlights

D8L100136

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
98PCMW8-08 12/09/98 12:30 001				
Benzene	0.82	0.50	ug/L	CFR136A 602
Benzene	0.82	0.50	ug/L	CFR136A 602
Benzene	1.1	0.50	ug/L	CFR136A 602
Ethylbenzene	3.6	0.50	ug/L	CFR136A 602
Ethylbenzene	3.6	0.50	ug/L	CFR136A 602
Ethylbenzene	3.9	0.50	ug/L	CFR136A 602
Toluene	0.43 J,B	0.50	ug/L	CFR136A 602
Toluene	0.43 J,B	0.50	ug/L	CFR136A 602
Toluene	0.16 J,B	0.50	ug/L	CFR136A 602
Xylenes (total)	2.9 B	0.50	ug/L	CFR136A 602
Xylenes (total)	2.9 B	0.50	ug/L	CFR136A 602
Xylenes (total)	3.3 B	0.50	ug/L	CFR136A 602
Naphthalene	29	1.0	ug/L	SW846 8310
Naphthalene	29	1.0	ug/L	SW846 8310
Naphthalene	34	1.0	ug/L	SW846 8310
Phenanthrene	1.5	0.20	ug/L	SW846 8310
Phenanthrene	1.5	0.20	ug/L	SW846 8310
Phenanthrene	1.4	0.20	ug/L	SW846 8310
Acenaphthene	1.6 J	10	ug/L	CFR136A 625
Fluorene	2.2 J	10	ug/L	CFR136A 625
Naphthalene	26	10	ug/L	CFR136A 625
Phenanthrene	1.4 J	10	ug/L	CFR136A 625
98PCMW8-09 12/09/98 11:25 002				
Methane	1.5 B	0.50	ug/L	EPA-9 RSK-175
Nitrate	2.5	1.0	mg/L	SW846 9056
98PCMW8-06 12/09/98 10:20 003				
Methane	0.13 J,B	0.50	ug/L	EPA-9 RSK-175
Nitrate	2.4	1.0	mg/L	SW846 9056
98PCMW8-11 12/09/98 14:40 004				
Methane	300 B,E	0.50	ug/L	EPA-9 RSK-175
Methane	690 B,D	5.0	ug/L	EPA-9 RSK-175
TRIPBLANK 12/09/98 005				
Xylenes (total)	0.22 J,B	0.50	ug/L	CFR136A 602
Xylenes (total)	0.22 J,B	0.50	ug/L	CFR136A 602
Xylenes (total)	0.40 J,B	0.50	ug/L	CFR136A 602

(Continued on next page)



# EXECUTIVE SUMMARY - Detection Highlights

D8L100136

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>ANALYTICAL METHOD</u>
98POMP8-C 12/09/98 09:30 006				
Xylenes (total)	0.24 J,B	0.50	ug/L	CFR136A 602
Xylenes (total)	0.24 J,B	0.50	ug/L	CFR136A 602
Xylenes (total)	0.46 J,B	0.50	ug/L	CFR136A 602

# ANALYTICAL METHODS SUMMARY

D8L100136

<u>PARAMETER</u>	<u>ANALYTICAL METHOD</u>
Base/Neutrals and Acids	CFR136A 625
Dissolved Gasses in Water	EPA-9 RSK-175
Nitrate as N	SW846 9056
Polynuclear Aromatic Hydrocarbons by HPLC	SW846 8310
Purgeable Aromatics	CFR136A 602

## References:

- CFR136A "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.
- EPA-9 Sample Prep and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, RSKSOP-175, REV. 0, 8/11/94, USEPA Research Lab
- SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

## METHOD / ANALYST SUMMARY

D8L100136

<u>ANALYTICAL METHOD</u>	<u>ANALYST</u>	<u>ANALYST ID</u>
CFR136A 602	Shawn Hadley	060376
CFR136A 625	Robert P. Guthrie	001593
EPA-9 RSK-175	Brook Derenzy	005830
SW846 8310	Dane Rodgers	007407
SW846 9056	Patty Jungk	002008

### References:

CFR136A "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

EPA-9 Sample Prep and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, RSKSOP-175, REV. 0, 8/11/94, USEPA Research Lab

SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

## SAMPLE SUMMARY

D8L100136

WO #	SAMPLE#	CLIENT SAMPLE ID	DATE	TIME
CP64D	001	98POMW8-08	12/09/98	12:30
CP64M	002	98POMW8-09	12/09/98	11:25
CP64P	003	98POMW8-06	12/09/98	10:20
CP64Q	004	98POMW8-11	12/09/98	14:40
CP64R	005	TRIPBLANK	12/09/98	
CP64X	006	98POMP8-C	12/09/98	09:30

### NOTE(S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-08

## GC/MS Semivolatiles

Lot-Sample #....: D8L100136-001 Work Order #....: CP64D101 Matrix.....: WG  
 Date Sampled....: 12/09/98 12:30 Date Received...: 12/10/98  
 Prep Date.....: 12/10/98 Analysis Date...: 01/14/99  
 Prep Batch #....: 8344205 Analysis Time...: 03:14  
 Dilution Factor: 1

Method.....: CFR136A 625

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Acenaphthene	1.6 J	10	ug/L
Acenaphthylene	ND	10	ug/L
Anthracene	ND	10	ug/L
Benzidine	ND	100	ug/L
Benzo(a)anthracene	ND	10	ug/L
Benzo(b)fluoranthene	ND	10	ug/L
Benzo(ghi)perylene	ND	10	ug/L
Benzo(k)fluoranthene	ND	10	ug/L
Benzo(a)pyrene	ND	10	ug/L
4-Bromophenyl phenyl ether	ND	10	ug/L
Butyl benzyl phthalate	ND	10	ug/L
bis(2-Chloroethoxy) methane	ND	10	ug/L
bis(2-Chloroethyl) ether	ND	10	ug/L
bis(2-Chloroisopropyl) ether	ND	10	ug/L
4-Chloro-3-methylphenol	ND	10	ug/L
2-Chloronaphthalene	ND	10	ug/L
2-Chlorophenol	ND	10	ug/L
4-Chlorophenyl phenyl ether	ND	10	ug/L
Chrysene	ND	10	ug/L
Di-n-butyl phthalate	ND	10	ug/L
1,2-Dichlorobenzene	ND	10	ug/L
1,3-Dichlorobenzene	ND	10	ug/L
1,4-Dichlorobenzene	ND	10	ug/L
3,3'-Dichlorobenzidine	ND	50	ug/L
2,4-Dichlorophenol	ND	10	ug/L
Diethyl phthalate	ND	10	ug/L
2,4-Dimethylphenol	ND	10	ug/L
Dimethyl phthalate	ND	10	ug/L
2,4-Dinitrophenol	ND	50	ug/L
2,4-Dinitrotoluene	ND	10	ug/L
2,6-Dinitrotoluene	ND	10	ug/L
Di-n-octyl phthalate	ND	10	ug/L
1,2-Diphenylhydrazine	ND	10	ug/L
bis(2-Ethylhexyl) phthalate	ND	10	ug/L

(Continued on next page)

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-08

## GC/MS Semivolatiles

Lot-Sample #....: D8L100136-001 Work Order #....: CP64D101 Matrix.....: WG

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Fluoranthene	ND	10	ug/L
Fluorene	2.2 J	10	ug/L
Hexachlorobenzene	ND	10	ug/L
Hexachlorobutadiene	ND	10	ug/L
Hexachlorocyclopentadiene	ND	50	ug/L
Hexachloroethane	ND	10	ug/L
Indeno (1,2,3-cd) pyrene	ND	10	ug/L
Isophorone	ND	10	ug/L
Naphthalene	26	10	ug/L
Nitrobenzene	ND	10	ug/L
2-Nitrophenol	ND	10	ug/L
4-Nitrophenol	ND	50	ug/L
N-Nitrosodimethylamine	ND	10	ug/L
N-Nitrosodi-n-propylamine	ND	10	ug/L
N-Nitrosodiphenylamine	ND	10	ug/L
Pentachlorophenol	ND	50	ug/L
Phenanthrene	1.4 J	10	ug/L
Phenol	ND	10	ug/L
Pyrene	ND	10	ug/L
1,2,4-Trichlorobenzene	ND	10	ug/L
2,4,6-Trichlorophenol	ND	10	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
2-Fluorophenol	88	(48 - 102)
Phenol-d5	89	(46 - 110)
Nitrobenzene-d5	73	(51 - 102)
2-Fluorobiphenyl	67	(39 - 91 )
2,4,6-Tribromophenol	93	(38 - 120)
Terphenyl-d14	73	(42 - 131)

## NOTE (S) :

J Estimated result. Result is less than RL.

## PARSONS ENGINEERING SCIENCE, INC.

98POMW8-08

## GC/MS Semivolatiles

Lot-Sample #: D8L100136-001

Work Order #: CP64D101

Matrix: WG

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Benzene, (1-methyl-1-propenyl)	767-99-7	14	M	ug/L
Naphthalene, 2-methyl-	91-57-6	53	M	ug/L
Naphthalene, 1-methyl-	90-12-0	42	M	ug/L
1(2H)-naphthalenone, 3,4-dihyd	529-34-0	13	M	ug/L
Unknown	57-20-0	0.0	M	ug/L
Naphthalene, 2,6-dimethyl-	581-42-0	18	M	ug/L
Naphthalene, 2,7-dimethyl-	582-16-1	20	M	ug/L

NOTE(S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98PCMW8-08

## GC Volatiles

Lot-Sample #....: D8L100136-001    Work Order #....: CP64D102    Matrix.....: WG  
Date Sampled....: 12/09/98 12:30    Date Received...: 12/10/98  
Prep Date.....: 12/11/98    Analysis Date...: 12/11/98  
Prep Batch #....: 8348344    Analysis Time...: 13:43  
Dilution Factor: 1  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	0.82	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	3.6	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	0.43 J,B	0.50	ug/L
Xylenes (total)	2.9 B	0.50	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	89	(82 - 112)

## NOTE(S):

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

1C



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-08

## GC Volatiles

Lot-Sample #....: D8L100136-001    Work Order #....: CP64D10A    Matrix.....: WG  
Date Sampled....: 12/09/98 12:30    Date Received...: 12/10/98  
Prep Date.....: 12/11/98    Analysis Date...: 12/11/98  
Prep Batch #....: 8348344    Analysis Time...: 13:43  
Dilution Factor: 1  
Method.....: CFR136A 602

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Benzene	1.1	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	3.9	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	0.16 J,B	0.50	ug/L
Xylenes (total)	3.3 B	0.50	ug/L

<u>SURROGATE</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>
a,a,a-Trifluorotoluene (TFT)	105	(82 - 112)

NOTE(S) :

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-C

## GC Volatiles

Lot-Sample #....: D8L100136-006 Work Order #....: CP64X101 Matrix.....: WG  
Date Sampled....: 12/09/98 09:30 Date Received...: 12/10/98  
Prep Date.....: 12/11/98 Analysis Date...: 12/11/98  
Prep Batch #....: 8348344 Analysis Time...: 15:28  
Dilution Factor: 1  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Benzene	ND	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	ND	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	ND	0.50	ug/L
Xylenes (total)	0.24 J,B	0.50	ug/L

SURROGATE	PERCENT	RECOVERY
	RECOVERY	LIMITS
a,a,a-Trifluorotoluene (TFT)	88	(82 - 112)

## NOTE(S):

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

1C

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-C

GC Volatiles

Lot-Sample #....: D8L100136-006 Work Order #....: CP64X102 Matrix.....: WG  
 Date Sampled....: 12/09/98 09:30 Date Received...: 12/10/98  
 Prep Date.....: 12/11/98 Analysis Date...: 12/11/98  
 Prep Batch #....: 8348344 Analysis Time...: 15:28  
 Dilution Factor: 1  
 Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	ND	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	ND	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	ND	0.50	ug/L
Xylenes (total)	0.46 J,B	0.50	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	91	(82 - 112)

NOTE(S) :

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-08

## HPLC

Lot-Sample #...: D8L100136-001 Work Order #...: CP64D103 Matrix.....: WG  
Date Sampled...: 12/09/98 12:30 Date Received...: 12/10/98  
Prep Date.....: 12/16/98 Analysis Date...: 01/06/99  
Prep Batch #...: 8350102 Analysis Time...: 16:05  
Dilution Factor: 1  
Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	1.0	ug/L
Acenaphthylene	ND	1.0	ug/L
Anthracene	ND	0.10	ug/L
Benzo(a)anthracene	ND	0.13	ug/L
Benzo(a)pyrene	ND	0.23	ug/L
Benzo(b)fluoranthene	ND	0.18	ug/L
Benzo(ghi)perylene	ND	0.20	ug/L
Benzo(k)fluoranthene	ND	0.17	ug/L
Chrysene	ND	0.20	ug/L
Dibenzo(a,h)anthracene	ND	0.30	ug/L
Fluoranthene	ND	0.20	ug/L
Fluorene	ND	0.20	ug/L
Indeno(1,2,3-cd)pyrene	ND	0.43	ug/L
Naphthalene	29	1.0	ug/L
Phenanthrene	1.5	0.20	ug/L
Pyrene	ND	0.20	ug/L
	PERCENT	RECOVERY	
SURROGATE	RECOVERY	LIMITS	
Terphenyl-d14	69	(25 - 157)	

NOTE(S):

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-08

## HPLC

Lot-Sample #....: D8L100136-001    Work Order #....: CP64D10C    Matrix.....: WG  
 Date Sampled....: 12/09/98 12:30    Date Received...: 12/10/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/06/99  
 Prep Batch #....: 8350102    Analysis Time...: 16:05  
 Dilution Factor: 1  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	1.0	ug/L
Acenaphthylene	ND	1.0	ug/L
Anthracene	ND	0.10	ug/L
Benzo(a) anthracene	ND	0.13	ug/L
Benzo(a) pyrene	ND	0.23	ug/L
Benzo(b) fluoranthene	ND	0.18	ug/L
Benzo(ghi) perylene	ND	0.20	ug/L
Benzo(k) fluoranthene	ND	0.17	ug/L
Chrysene	ND	0.20	ug/L
Dibenzo(a,h) anthracene	ND	0.30	ug/L
Fluoranthene	ND	0.20	ug/L
Fluorene	ND	0.20	ug/L
Indeno(1,2,3-cd) pyrene	ND	0.43	ug/L
Naphthalene	34	1.0	ug/L
Phenanthrene	1.4	0.20	ug/L
Pyrene	ND	0.20	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
Terphenyl-d14	79	(25 - 157)

NOTE(S) :

2C

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-09

General Chemistry

Lot-Sample #....: D8L100136-002    Work Order #....: CP64M  
Date Sampled....: 12/09/98 11:25    Date Received...: 12/10/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	2.5	1.0	mg/L	SW846 9056	12/10-12/11/98	8346199
Dilution Factor: 1				Analysis Time...: 06:46		

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-09

General Chemistry

Lot-Sample #....: D8L100136-002    Work Order #....: CP64M  
Date Sampled....: 12/09/98 11:25    Date Received...: 12/10/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	2.5	1.0	mg/L	SW846 9056	12/10-12/11/98	8346199

Dilution Factor: 1                      Analysis Time...: 06:46

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-06

General Chemistry

Lot-Sample #....: D8L100136-003    Work Order #....: CP64P  
Date Sampled....: 12/09/98 10:20    Date Received...: 12/10/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	2.4	1.0	mg/L	SW846 9056	12/10-12/11/98	8346199

Dilution Factor: 1                      Analysis Time...: 07:56



PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

General Chemistry

Lot-Sample #....: D8L100136-004    Work Order #....: CP64Q  
Date Sampled....: 12/09/98 14:40    Date Received...: 12/10/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	ND	1.0	mg/L	SW846 9056	12/10-12/11/98	8346199

Dilution Factor: 1                      Analysis Time...: 08:19

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-09

GC Volatiles

Lot-Sample #....: D8L100136-002    Work Order #....: CP64M104    Matrix.....: WG  
Date Sampled....: 12/09/98 11:25    Date Received...: 12/10/98  
Prep Date.....: 12/22/98    Analysis Date...: 12/22/98  
Prep Batch #....: 8357282    Analysis Time...: 15:54  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Methane	1.5 B	0.50	ug/L

NOTE(S) :

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-06

GC Volatiles

Lot-Sample #....: D8L100136-003 Work Order #....: CP64P102 Matrix.....: WG  
Date Sampled....: 12/09/98 10:20 Date Received...: 12/10/98  
Prep Date.....: 12/22/98 Analysis Date...: 12/22/98  
Prep Batch #....: 8357282 Analysis Time...: 15:54  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Methane	0.13 J,B	0.50	ug/L

NOTE(S):

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98PCMW8-11

GC Volatiles

Lot-Sample #....: D8L100136-004    Work Order #....: CP64Q102    Matrix.....: WG  
Date Sampled....: 12/09/98 14:40    Date Received...: 12/10/98  
Prep Date.....: 12/22/98    Analysis Date...: 12/22/98  
Prep Batch #....: 8357282    Analysis Time...: 16:19  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u> <u>LIMIT</u>	<u>UNITS</u>
Methane	300 B,E	0.50	ug/L

NOTE(S) :

- B Method blank contamination. The associated method blank contains the target analyte at a reportable level.  
E Estimated result. Result concentration exceeds the calibration range.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

GC Volatiles

Lot-Sample #...: D8L100136-004 Work Order #...: CP64Q202 Matrix.....: WG  
Date Sampled...: 12/09/98 14:40 Date Received...: 12/10/98  
Prep Date.....: 12/23/98 Analysis Date...: 12/23/98  
Prep Batch #...: 8357316 Analysis Time...: 13:22  
Dilution Factor: 10  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Methane	690 B,D	5.0	ug/L

NOTE (S) :

- B Method blank contamination. The associated method blank contains the target analyte at a reportable level.  
D Result was obtained from the analysis of a dilution.

**Laboratory Non-Conformance  
Memo (NCM)**

QUA-4187	D8L100136-001, MS, SD	NCM Log Number	15897
Project ID/Client	D8L110138-001, 003	Sample Numbers	
8350102	D8L120137-001	NCM Initiated by/Date	Project Manager
Analysis/Team		D8L1/18/99	E. La Riviere

Tests  
**8310 PAH**

**Analytical Area (check appropriate box)**

- |                                         |                                              |                                                |                                         |                                          |                                |                                        |
|-----------------------------------------|----------------------------------------------|------------------------------------------------|-----------------------------------------|------------------------------------------|--------------------------------|----------------------------------------|
| <input type="checkbox"/> Sample control | <input type="checkbox"/> Organic preparation | <input type="checkbox"/> Inorganic preparation | <input type="checkbox"/> GC             | <input checked="" type="checkbox"/> HPLC | <input type="checkbox"/> GC/MS | <input type="checkbox"/> Wet chemistry |
| <input type="checkbox"/> Metals         | <input type="checkbox"/> Reporting           | <input type="checkbox"/> Data review           | <input type="checkbox"/> Radiochemistry | <input type="checkbox"/>                 | <input type="checkbox"/>       | <input type="checkbox"/>               |

**Non-Conformance (check appropriate box) To be completed by analyst**

**Holding Time Violation (exceeded by \_\_\_\_\_ days)**

**Category I: Laboratory Independent**

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

**Category II: Laboratory Dependent**

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required) \_\_\_\_\_

**Category III: Analysis Reruns (QA/QC)**

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

**Category IV: Analysis Reruns (Confirmation)**

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required) \_\_\_\_\_

**Quality Assurance/Quality Control**

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

**Incorrect or Incomplete Client Deliverable**

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

**Reported Detection Limits Elevated Due to:**

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required) \_\_\_\_\_

**Miscellaneous**

- ☐ 27. Instrument Tag-out
- ☐ 28. Other (explanation required) \_\_\_\_\_

**Notification (check appropriate box) To be completed by project manager**

☐ Required ☒ Not Required

Notified by - Name	Date	<input type="checkbox"/> In writing	<input type="checkbox"/> By telephone	<input type="checkbox"/> By facsimile	<input type="checkbox"/> Other (explain) _____
Client's name and response	<input type="checkbox"/> Process "as is"	<input type="checkbox"/> On hold until _____	<input type="checkbox"/> Re-sample	<input type="checkbox"/> Other (explain) _____	
Project manager signature	Date				56
<i>E. La Riviere</i>	1/18/99				

Laboratory Non-Conformance  
Memo (NCM)

IA-4187

NCM Log Number

15897

Corrective Action (To be completed and reviewed by all associates involved)

Problem Description/Root Cause

Recoveries for dibenzo (a,h) anthracene are high for both LCS (109% max is 103% and LCSD (119% max is 103%)

Author's initials and date

Doc 11/18/99

Corrective Actions (Short Term)

there are no hits for dibenzo (a,h) anthracene in samples

Author's initials and date

Doc 11/18/99

Corrective Actions to Prevent Reoccurrence (Long Term)

Corrective Action approved by (Supervisor/Group Leader) and date

Additional Comments

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

Quality Assurance Review (To be completed by a QA associate)

Log ID ☐ Anomaly ☒ Deficiency ☐ Notified Ops/Sys Manager (Initials)

☐ Further action required

☐ Further action assigned to

QA signature

Thom Khumwan

Date

1/19/99

Corrective Action Verification (To be completed by a QA associate)

☐ Verification not required or requested ☐ Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐ Cannot verify (specify reason) \_\_\_\_\_

ed by

Date

Nonconformance Memo Closure

QA signature

Thom Khumwan

Date

1/19/99

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

Laboratory Non-Conformance  
Memo (NCM)

8744205

QUA-4187	08L050133-01, -02	NCM Log Number <b>15695</b>		
Project ID/Client 08L090209-03 08L100136-01	PARSONS	Sample Numbers	NCM Initiated by/Date E 1-15-99	Project Manager LARIVIAK
Analyst/Team E/BNA				

Tests  
625

Analytical Area (check appropriate box)

<input type="checkbox"/> Sample control	<input type="checkbox"/> Organic preparation	<input type="checkbox"/> Inorganic preparation	<input type="checkbox"/> GC	<input type="checkbox"/> HPLC	<input checked="" type="checkbox"/> GC/MS	<input type="checkbox"/> Wet chemistry
<input type="checkbox"/> Metals	<input type="checkbox"/> Reporting	<input type="checkbox"/> Data review	<input type="checkbox"/> Radiochemistry			

Non-Conformance (check appropriate box) To be completed by analyst

Holding Time Violation (exceeded by \_\_\_\_\_ days)

Category I: Laboratory Independent

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

Category II: Laboratory Dependent

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required)

Category III: Analysis Reruns (QA/QC)

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

Category IV: Analysis Reruns (Confirmation)

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required)

Quality Assurance/Quality Control

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

Incorrect or Incomplete Client Deliverable

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

Reported Detection Limits Elevated Due to:

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required)

Miscellaneous

- ☐ 27. Instrument Tag-out
- ☒ 28. Other (explanation required)

EXPIRED LCS / MS STANDARD (V11292)  
USED BECAUSE LAB RAN OUT OF  
STANDARD AND THE SAMPLES WOULD  
HAVE EXPIRED PRIOR TO RECEIPT  
OF A REPLACEMENT STANDARD.

Notification (check appropriate box) To be completed by project manager

☐ Required ☐ Not Required

Notified by - Name	Date	<input type="checkbox"/> In writing	<input type="checkbox"/> By telephone	<input type="checkbox"/> By facsimile	<input type="checkbox"/> Other (explain)
Analyst's name and response	<input type="checkbox"/> Process "as is" <input type="checkbox"/> On hold until _____ <input type="checkbox"/> Re-sample <input type="checkbox"/> Other (explain)				

Project manager signature: Allen Larivian Date: 1/18/99 47



**Laboratory Non-Conformance  
Memo (NCM)**

4-4187

NCM Log Number

15695

**Corrective Action (To be completed and reviewed by all associates involved)**

Problem Description/Root Cause

SEE ATTACHMENT

Author's initials and date

R 1-15-99

**Corrective Actions (Short Term)**

THE SAMPLES HAVE EXPIRED. NOTIFY CLIENT PRIOR TO TAKING CORRECTIVE ACTION.

Author's initials and date

R 1-15-99

**Corrective Actions to Prevent Recurrence (Long Term)**

ENSURE THAT STANDARDS ARE APPLIED PRIOR TO REPLICATION.

Corrective Action approved by (Supervisor/Group Leader) and date

R 1-15-99

**Additional Comments**

**Corrective Action to be completed by (if other than Supervisor/Group Leader)**

**Date Corrective Action is to be completed**

**Quality Assurance Review (To be completed by a QA associate)**

Log ID ☐ Anomaly ☒ Deficiency ☐ Notified Ops/Sys Manager (Initials)

☐ Further action required

☐ Further action assigned to

QA signature

Date

**Corrective Action Verification (To be completed by a QA associate)**

☐ Verification not required or requested

☐ Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐ Cannot verify (specify reason) \_\_\_\_\_

by

Date

**Nonconformance Memo Closure**

QA signature

Date

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

Page: 12 of 24  
Lot #: D86100136 Date/Time Received: 12/10/98 0900

Company Name & Sampling Site: PARSONS

\*Cooler #(s): \_\_\_\_\_  
Temperature: 24 \_\_\_\_\_

Unpacking & Labeling Check Points:

- | Y/A                                                                                                        | Yes                                 | No                       |                                                                                                |                       |           |
|------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------|------------------------------------------------------------------------------------------------|-----------------------|-----------|
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 1. Radiation checked, record if reading > 0.5 mR/hr.                                           | (_____ mR/hr)         | <u>NO</u> |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 2. Cooler seals intact.                                                                        |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 3. Chain of custody present.                                                                   |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 4. Bottles broken and/or are leaking, comment if yes.                                          |                       |           |
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">PHOTOGRAPH BROKEN BOTTLES</div> |                                     |                          |                                                                                                |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 5. Containers labeled, comment if no.                                                          |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 6. pH of all samples checked and meet requirements, note exceptions.                           |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 7. Chain of custody includes "received by" and "relinquished" by signatures, dates, and times. |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 8. Receipt date(s) > 48 hours past the collection date(s)? If yes, notify PA/PM.               |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 9. Chain of custody agrees with bottle count, comment if no.                                   | <u>There are</u>      |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 10. Chain of custody agrees with labels, comment if no.                                        | <u>2 bottles each</u> |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 11. VOA samples filled completely, comment if no.                                              | <u>for MSD's, and</u> |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 12. VOA bottles preserved, check for labels.                                                   | <u>only 1 bottle</u>  |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 13. Did samples require preservation with sodium thiosulfate?                                  | <u>for MS's.</u>      |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 14. If yes to #12, did the samples contain residual chlorine?                                  |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 15. Sediment present in "D," dissolved, bottles.                                               |                       |           |
| <input checked="" type="checkbox"/>                                                                        | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 16. Are analyses with short holding times requested?                                           |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 17. Is extra sample volume provided for MS, MSD or matrix duplicates?                          |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 18. Multiphase samples present? If yes, comment below.                                         |                       |           |
| <input type="checkbox"/>                                                                                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | 19. Any subsampling for volatiles? If yes, list samples.                                       |                       |           |

PHOTOGRAPH MULTIPHASE SAMPLES

- |                          |                          |                          |                                                                   |  |
|--------------------------|--------------------------|--------------------------|-------------------------------------------------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Clear picture taken, labeled, and stapled to project folder.  |  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Subcontract: CCC signed and sent with samples to bottle prep? |  |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 22. Was sample labeling double checked?                           |  |

Comments: Include action taken to resolve discrepancies/problems. Include a hard copy of e-mail or use extra paper if more space is needed.

Initials: \_\_\_\_\_

QUA-4124 0797

Client: Parsons Engineering Science, Inc. Project Manager: John Hicks Date: 12/9/98 Chain of Custody Number: 20257

Address: 1700 Broadway Suite 900 Telephone Number (Area Code)/Fax Number: 830-831-8100 Lab Number: DBL100136 Page: 1 of 2

City: Denver State: CO Zip Code: 80240 Site Contact: 10m Driggs Lab Contact: E/11m

Project Name: AFCEE RBIA Investigation Contract/Purchase Order/Quote No.: 7318541.04000

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix					Containers & Preservatives					Analysis (Attach list if more space is needed)										Special Instructions/ Conditions of Receipt
			Soil	Sed.	Unknown	Soil	Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc	NrOH	625 (MS)	625 (MS)	625 (MS)	625 (MS)	625 (MS)	625 (MS)	625 (MS)	625 (MS)	625 (MS)	
1 98PO MW8-08	12/9/98	1230	X				X							X									2-1 Liter Amber
2 98PO MW8-08	12/9/98	1230	X				X							X									1-1 Liter Amber
3 98PO MW8-08	12/9/98	1230	X				X							X									2-1 Liter Amber
4 98PO MW8-08	12/9/98	1230	X				X							X									2-1 Liter Amber
5 98PO MW8-08	12/9/98	1230	X				X							X									1-1 Liter Amber
6 98PO MW8-08	12/9/98	1230	X				X							X									2-1 Liter Amber
7 98PO MW8-08	12/9/98	1230	X				X							X									3- Vials
8 98PO MW8-08	12/9/98	1230	X				X							X									3- Vials
9 98PO MW8-08	12/9/98	1230	X				X							X									3- Vials
10 98PO MW8-09	12/9/98	1125	X				X							X									1-1 Liter Poly
11 98PO MW8-09	12/9/98	1125	X				X							X									1-1 Liter Poly
12 98PO MW8-09	12/9/98	1125	X				X							X									1-1 Liter Poly

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown ☐ Return To Client ☐ Disposal By Lab ☒ Archive For 3 Months (A lee may be assessed if samples are retained longer than 3 months)

QC Requirements (Specify): Only have (1) one Liter sample for 625 (MS) & 8310 (MS) on Nitrate!

1. Relinquished By: [Signature] Date: 12/9/98 Time: 1830

2. Relinquished By: [Signature] Date: 12/9/98 Time: 1830

3. Relinquished By: [Signature] Date: 12/9/98 Time: 1830

Please identify 10 largest non-target peaks for Method 625 SVOC

DISTRIBUTION: WHITE - Slays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy



# Custody Record

OUA-4124 0787

Client

Parsons Engineering Science, Inc.  
1700 Broadway Suite 900  
Denver

Project Manager

John Hicks

Telephone Number (Area Code)/Fax Number

303-831-8100

Date

12/11/98

Chain of Custody Number

1050

City

State

Zip Code

CO 80290

Site Contact

1. D. Drake

Lab Contact

Ellen Levine

Page

1 of 1

Project Name

AFCEE RBCA Investigation  
Contract/Purchase Order/Quote No.

Carrier/Waybill Number

98-8203

Analysis (Attach list if more space is needed)

METHANE ASK-175 (M)

METHANE ASK-175 (M)

METHANE ASK-175 (M)

Containers & Preservatives

HCl

HNO3

H2SO4

Unpres

Matrix

Aqueous

Soil

Sed.

Date

Time

Sample I.D. No. and Description  
(Containers for each sample may be combined on one line)

98POMF8-A 12-10-98 7:55:30 X

98PO MW8-09 12-9-98 11:25 X

98PO MW8-11 12-9-98 14:40 X

98PO MW8-6 12-9-98 10:20 X

98PO MF8-B 12-10-98 9:20 X

Special Instructions/  
Conditions of Receipt

91045 (3 sets of

Possible Hazard Identification

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Turn Around Time Required

☐ 24 Hours ☒ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other

1. Relinquished By

2. Relinquished By

3. Relinquished By

Comments

Sample Disposal

☐ Return To Client ☐ Disposal By Lab ☐ Archive For

Months

(A fee may be assessed if samples are retained longer than 3 months)

OC Requirements (Specify)

1. Received By

2. Received By

Date

Time

Date

Time

Date

Time

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

## ANALYTICAL REPORT

Pope AFB  
Lot #: D8L120137

John Hicks  
Parsons Engineering Services

QUANTERRA INCORPORATED

A handwritten signature in cursive script, reading 'Ellen La Riviere'.  
Ellen La Riviere  
Project Manager

January 25, 1999

# Table Of Contents

## Standard Deliverables with Supporting Documentation

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	<b>Supporting Documentation</b>	
	<i>[Please Note: A one-page "Description of Supporting Documentation" is provided in the Supporting Documentation section(s).]</i>	
B.	• Volatile GC/MS	
C.	• Semivolatile GC/MS	
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# Project Narrative

(D8L120137)

## GC/MS Volatiles

Due to the concentration of target compounds present, samples D8L120137-005 and -006 were extracted as medium level soils. Due to the extraction procedure, dichlorodifluoromethane was recovered below the lower control limits in the LCS/LCSD associated with the samples. The client was contacted on December 21, 1998. Because these were not compounds of concern for the site, no further action was required.

## GC/MS Semi-Volatiles

Due to laboratory error, samples D8L120137-005 and -006 were never extracted for Method 8270. The client was contacted on January 19, 1999 and requested the laboratory not perform the extraction outside of holding time. Therefore, the Method 8270 analyses were canceled for these samples.

The extraction lab ran out of all analyte spike, and it was not possible to obtain a new supply prior to sample expiration. Therefore, an expired all analyte spike standard (V11292) was used to prepare the LCS/LCSD and MS/MSD for QC Batch 8349353. The expired standard was re-verified, but the re-verification showed that benzidine and 3,3'-dichlorobenzidine had degraded and were no longer present in the expired standard.

The MS is the primary control sample for Method 625. The LCS is used as a backup for the MS.

As expected, Benzidine and 3,3'-Dichlorobenzidine were not detected in the LCS/LCSD. Since it was shown that Benzidine and 3,3'-Dichlorobenzidine were not present in the spiking standard, corrective action was not initiated when these compounds were not found in the LCS/LCSD.

The RPD for diethylphthalate exceeded the control limit in the LCS/LCSD. This was unrelated to the use of the expired standard. However, Method 625 has no RPD criteria because it does not require the analysis of a LCSD, and diethylphthalate was not detected in any sample above the reporting limit. Therefore, no corrective was taken for this problem.

An additional problem for Lot D8L120137 was poor recovery of hexachlorocyclopentadiene. Hexachlorocyclopentadiene was out of control for the LCS with a recovery of 0% (the lower control limit for this compound is 2.0%). Hexachlorocyclopentadiene was in control for the LCSD with a recovery of 2.8%. This was unrelated to the use of the expired standard. According to Method 625, hexachlorocyclopentadiene is not listed as a control analyte for a LCS. Therefore, no corrective was taken for this problem.

## GC Volatiles

The Method 602 surrogate, a,a,a-trifluorotoluene, was recovered above the upper control limit on the secondary column associated with sample D8L120137-001. This surrogate is a co-eluting compound on the secondary column. Because a,a,a-trifluorotoluene was within acceptable limits on the primary column, no further action was required.



### **Polynuclear Aromatic Hydrocarbons**

Dibenzo(a,h)anthracene was recovered above the upper control limits in the LCS/LCSD associated with the samples in this project. Because this would indicate a high bias to the data, and this compound was not detected in the samples, no further action was required.

### **General Chemistry**

The total recoverable petroleum hydrocarbons analysis was performed by Quanterra's laboratory located in Austin, Texas.

# EXECUTIVE SUMMARY - Detection Highlights

D8L120137

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
98PCMP8-A 12/10/98 15:30 001				
Benzene	27	12	ug/L	CFR136A 602
Benzene	27	12	ug/L	CFR136A 602
Benzene	25	12	ug/L	CFR136A 602
Ethylbenzene	220	12	ug/L	CFR136A 602
Ethylbenzene	220	12	ug/L	CFR136A 602
Ethylbenzene	210	12	ug/L	CFR136A 602
Toluene	100	12	ug/L	CFR136A 602
Toluene	100	12	ug/L	CFR136A 602
Toluene	60	12	ug/L	CFR136A 602
Xylenes (total)	950	12	ug/L	CFR136A 602
Xylenes (total)	950	12	ug/L	CFR136A 602
Xylenes (total)	920	12	ug/L	CFR136A 602
Anthracene	3.5	0.50	ug/L	SW846 8310
Anthracene	3.5	0.50	ug/L	SW846 8310
Anthracene	2.5	0.50	ug/L	SW846 8310
Benzo (a) pyrene	1.1 F	1.2	ug/L	SW846 8310
Benzo (a) pyrene	1.1 F	1.2	ug/L	SW846 8310
Benzo (a) pyrene	1.3	1.2	ug/L	SW846 8310
Benzo (b) fluoranthene	1.0	0.90	ug/L	SW846 8310
Benzo (b) fluoranthene	1.0	0.90	ug/L	SW846 8310
Benzo (b) fluoranthene	1.5	0.90	ug/L	SW846 8310
Benzo (k) fluoranthene	0.70 F	0.85	ug/L	SW846 8310
Benzo (k) fluoranthene	0.70 F	0.85	ug/L	SW846 8310
Benzo (k) fluoranthene	0.53 F	0.85	ug/L	SW846 8310
Fluoranthene	20	1.0	ug/L	SW846 8310
Fluoranthene	20	1.0	ug/L	SW846 8310
Fluoranthene	8.6	1.0	ug/L	SW846 8310
Naphthalene	180	5.0	ug/L	SW846 8310
Naphthalene	180	5.0	ug/L	SW846 8310
Naphthalene	190	5.0	ug/L	SW846 8310
Phenanthrene	27	1.0	ug/L	SW846 8310
Phenanthrene	27	1.0	ug/L	SW846 8310
Phenanthrene	24	1.0	ug/L	SW846 8310
Acenaphthene	6.4 J	10	ug/L	CFR136A 625
Anthracene	1.6 J	10	ug/L	CFR136A 625
2,4-Dimethylphenol	4.1 J	10	ug/L	CFR136A 625
Fluoranthene	1.9 J	10	ug/L	CFR136A 625
Fluorene	7.8 J	10	ug/L	CFR136A 625
Naphthalene	140	10	ug/L	CFR136A 625
N-Nitrosodi-n-propylamine	1.5 J	10	ug/L	CFR136A 625
Phenanthrene	11	10	ug/L	CFR136A 625
Pyrene	1.5 J	10	ug/L	CFR136A 625

(Continued on next page)

# EXECUTIVE SUMMARY - Detection Highlights

D8L120137

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
98POSB3-12 12/11/98 14:30 005				
sec-Butylbenzene	0.21 F	0.95	mg/kg	SW846 8260A
Ethylbenzene	0.20 F	0.41	mg/kg	SW846 8260A
Isopropylbenzene	0.17 F	1.1	mg/kg	SW846 8260A
n-Propylbenzene	0.16 F	0.27	mg/kg	SW846 8260A
1,2,4-Trimethylbenzene	2.9	0.95	mg/kg	SW846 8260A
1,3,5-Trimethylbenzene	2.8	0.41	mg/kg	SW846 8260A
o-Xylene	0.13 F	0.68	mg/kg	SW846 8260A
m-Xylene & p-Xylene	1.4	0.41	mg/kg	SW846 8260A
Percent Moisture	8.1	0.10	%	MCAWW 160.3 MOD
98POSB4-12 12/11/98 11:00 006				
Methylene chloride	0.39 F	1.5	mg/kg	SW846 8260A
Naphthalene	2.1	1.5	mg/kg	SW846 8260A
1,2,4-Trimethylbenzene	0.96 F	2.0	mg/kg	SW846 8260A
o-Xylene	0.34 F	1.5	mg/kg	SW846 8260A
Percent Moisture	13.8	0.10	%	MCAWW 160.3 MOD
98POSB1-9.5 12/11/98 09:40 007				
Percent Moisture	10.9	0.50	%	ASTM D 2216-90
98POSB6-12 12/11/98 09:00 008				
Percent Moisture	15.8	0.10	%	MCAWW 160.3 MOD
98POSB5-12 12/11/98 08:15 009				
Percent Moisture	16.4	0.10	%	MCAWW 160.3 MOD
TRIP BLANK 12/11/98 010				
Chloroform	0.28 F	0.50	ug/L	SW846 8260A
1,4-Dichlorobenzene	0.44 F	0.50	ug/L	SW846 8260A
Methylene chloride	0.79 F,B	5.0	ug/L	SW846 8260A
Toluene	1.1	1.1	ug/L	SW846 8260A

# ANALYTICAL METHODS SUMMARY

D8L120137

<u>PARAMETER</u>	<u>ANALYTICAL METHOD</u>
Base/Neutrals and Acids	CFR136A 625
Method for Determination of Water Content of Soil	ASTM D 2216-90
Percent Moisture	MCAWW 160.3 MOD
Polynuclear Aromatic Hydrocarbons by HPLC	SW846 8310
Purgeable Aromatics	CFR136A 602
Total Organic Carbon	SW846 9060
Total Recoverable Petroleum Hydrocarbons	MCAWW 418.1
Volatile Organics by GC/MS	SW846 8260A

## References:

- ASTM      Annual Book Of ASTM Standards.
- CFR136A    "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.
- MCAWW      "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.
- SW846      "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

# METHOD / ANALYST SUMMARY

D8L120137

<u>ANALYTICAL METHOD</u>	<u>ANALYST</u>	<u>ANALYST ID</u>
ASTM D 2216-90	Lynette Scott	013264
CFR136A 602	Shawn Hadley	060376
CFR136A 625	Robert P. Guthrie	001593
MCAWW 160.3 MOD	Andrea Sporleder	001971
MCAWW 160.3 MOD	Duane Allee	001470
MCAWW 418.1	Robert Hook	011846
SW846 8260A	Mike G. Hoffman	001880
SW846 8310	Dane Rodgers	007407
SW846 9060	Ewa Kudla	001167

## References:

ASTM      Annual Book Of ASTM Standards.

CFR136A    "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

MCAWW      "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.

SW846      "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

# SAMPLE SUMMARY

D8L120137

WO #	SAMPLE#	CLIENT SAMPLE ID	DATE	TIME
CP913	001	98POMP8-A	12/10/98	15:30
CP91P	002	98POSW1	12/11/98	08:30
CP91X	003	98POSW2	12/11/98	08:40
CP934	005	98POSB3-12	12/11/98	14:30
CP935	006	98POSB4-12	12/11/98	11:00
CP936	007	98POSB1-9.5	12/11/98	09:40
CP937	008	98POSB6-12	12/11/98	09:00
CP938	009	98POSB5-12	12/11/98	08:15
CP939	010	TRIP BLANK	12/11/98	

## NOTE(S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB3-12

## GC/MS Volatiles

Lot-Sample #....: D8L120137-005    Work Order #....: CP934101    Matrix.....: SO  
 Date Sampled....: 12/11/98 14:30    Date Received...: 12/12/98  
 Prep Date.....: 12/18/98    Analysis Date...: 12/23/98  
 Prep Batch #....: 9021175    Analysis Time...: 16:57  
 Dilution Factor: 2.5  
 % Moisture.....: 8.1    Method.....: SW846 8260A

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Benzene	ND	0.27	mg/kg
Bromobenzene	ND	0.27	mg/kg
Bromochloromethane	ND	0.27	mg/kg
Bromodichloromethane	ND	0.54	mg/kg
Bromoform	ND	0.82	mg/kg
Bromomethane	ND	0.68	mg/kg
n-Butylbenzene	ND	0.68	mg/kg
sec-Butylbenzene	0.21 F	0.95	mg/kg
tert-Butylbenzene	ND	0.95	mg/kg
Carbon tetrachloride	ND	1.4	mg/kg
Chlorobenzene	ND	0.27	mg/kg
Chlorodibromomethane	ND	0.41	mg/kg
Chloroethane	ND	0.68	mg/kg
Chloroform	ND	0.27	mg/kg
1-Chlorohexane	ND	0.41	mg/kg
Chloromethane	ND	0.95	mg/kg
2-Chlorotoluene	ND	0.27	mg/kg
4-Chlorotoluene	ND	0.41	mg/kg
Dibromomethane	ND	1.4	mg/kg
1,2-Dichlorobenzene	ND	0.27	mg/kg
1,3-Dichlorobenzene	ND	0.82	mg/kg
1,4-Dichlorobenzene	ND	0.27	mg/kg
Dichlorodifluoromethane	ND	0.68	mg/kg
1,1-Dichloroethane	ND	0.27	mg/kg
1,2-Dichloroethane	ND	0.41	mg/kg
1,1-Dichloroethene	ND	0.82	mg/kg
cis-1,2-Dichloroethene	ND	0.82	mg/kg
trans-1,2-Dichloroethene	ND	0.41	mg/kg
1,2-Dichloropropane	ND	0.27	mg/kg
1,3-Dichloropropane	ND	0.27	mg/kg
2,2-Dichloropropane	ND	2.7	mg/kg
1,1-Dichloropropene	ND	0.68	mg/kg
cis-1,3-Dichloropropene	ND	0.68	mg/kg
trans-1,3-Dichloropropene	ND	0.68	mg/kg
Ethylbenzene	0.20 F	0.41	mg/kg
Trichlorofluoromethane	ND	0.54	mg/kg
Hexachlorobutadiene	ND	0.68	mg/kg
Isopropylbenzene	0.17 F	1.1	mg/kg

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## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB3-12

## GC/MS Volatiles

Lot-Sample #....: D8L120137-005 Work Order #....: CP934101 Matrix.....: SO

PARAMETER	RESULT	REPORTING LIMIT	UNITS
p-Isopropyltoluene	ND	0.82	mg/kg
Methylene chloride	ND	0.68	mg/kg
Naphthalene	ND	0.68	mg/kg
n-Propylbenzene	0.16 F	0.27	mg/kg
Styrene	ND	0.27	mg/kg
1,1,1,2-Tetrachloroethane	ND	0.41	mg/kg
1,1,2,2-Tetrachloroethane	ND	0.27	mg/kg
Tetrachloroethene	ND	0.95	mg/kg
Toluene	ND	0.68	mg/kg
1,2,3-Trichlorobenzene	ND	0.27	mg/kg
1,2,4-Trichlorobenzene	ND	0.27	mg/kg
1,1,1-Trichloroethane	ND	0.54	mg/kg
1,1,2-Trichloroethane	ND	0.68	mg/kg
Trichloroethene	ND	1.4	mg/kg
1,2,3-Trichloropropane	ND	2.7	mg/kg
1,2,4-Trimethylbenzene	2.9	0.95	mg/kg
1,3,5-Trimethylbenzene	2.8	0.41	mg/kg
Vinyl chloride	ND	1.2	mg/kg
o-Xylene	0.13 F	0.68	mg/kg
m-Xylene & p-Xylene	1.4	0.41	mg/kg
1,2-Dibromo-3-chloropropane (DBCP)	ND	1.4	mg/kg
1,2-Dibromoethane (EDB)	ND	0.41	mg/kg

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	96	(52 - 149)
4-Bromofluorobenzene	111	(65 - 135)
Toluene-d8	105	(65 - 135)
Dibromofluoromethane	86	(65 - 135)

**NOTE (S) :**

Results and reporting limits have been adjusted for dry weight.

F The analyte was identified but the value was below the RL and above the MDL.



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB4-12

## GC/MS Volatiles

Lot-Sample #....: D8L120137-006    Work Order #....: CP935101    Matrix.....: SO  
 Date Sampled....: 12/11/98 11:00    Date Received...: 12/12/98  
 Prep Date.....: 12/18/98    Analysis Date...: 12/23/98  
 Prep Batch #....: 9021175    Analysis Time...: 17:21  
 Dilution Factor: 5  
 % Moisture.....: 14    Method.....: SW846 8260A

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	ND	0.58	mg/kg
Bromobenzene	ND	0.58	mg/kg
Bromochloromethane	ND	0.58	mg/kg
Bromodichloromethane	ND	1.2	mg/kg
Bromoform	ND	1.7	mg/kg
Bromomethane	ND	1.5	mg/kg
n-Butylbenzene	ND	1.5	mg/kg
sec-Butylbenzene	ND	2.0	mg/kg
tert-Butylbenzene	ND	2.0	mg/kg
Carbon tetrachloride	ND	2.9	mg/kg
Chlorobenzene	ND	0.58	mg/kg
Chlorodibromomethane	ND	0.87	mg/kg
Chloroethane	ND	1.5	mg/kg
Chloroform	ND	0.58	mg/kg
1-Chlorohexane	ND	0.87	mg/kg
Chloromethane	ND	2.0	mg/kg
2-Chlorotoluene	ND	0.58	mg/kg
4-Chlorotoluene	ND	0.87	mg/kg
Dibromomethane	ND	2.9	mg/kg
1,2-Dichlorobenzene	ND	0.58	mg/kg
1,3-Dichlorobenzene	ND	1.7	mg/kg
1,4-Dichlorobenzene	ND	0.58	mg/kg
Dichlorodifluoromethane	ND	1.5	mg/kg
1,1-Dichloroethane	ND	0.58	mg/kg
1,2-Dichloroethane	ND	0.87	mg/kg
1,1-Dichloroethene	ND	1.7	mg/kg
cis-1,2-Dichloroethene	ND	1.7	mg/kg
trans-1,2-Dichloroethene	ND	0.87	mg/kg
1,2-Dichloropropane	ND	0.58	mg/kg
1,3-Dichloropropane	ND	0.58	mg/kg
2,2-Dichloropropane	ND	5.8	mg/kg
1,1-Dichloropropene	ND	1.5	mg/kg
cis-1,3-Dichloropropene	ND	1.5	mg/kg
trans-1,3-Dichloropropene	ND	1.5	mg/kg
Ethylbenzene	ND	0.87	mg/kg
Trichlorofluoromethane	ND	1.2	mg/kg
Hexachlorobutadiene	ND	1.5	mg/kg
Isopropylbenzene	ND	2.3	mg/kg

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## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB4-12

## GC/MS Volatiles

Lot-Sample #....: D8L120137-006 Work Order #....: CP935101 Matrix.....: SO

PARAMETER	RESULT	REPORTING LIMIT	UNITS
p-Isopropyltoluene	ND	1.7	mg/kg
Methylene chloride	0.39 F	1.5	mg/kg
Naphthalene	2.1	1.5	mg/kg
n-Propylbenzene	ND	0.58	mg/kg
Styrene	ND	0.58	mg/kg
1,1,1,2-Tetrachloroethane	ND	0.87	mg/kg
1,1,2,2-Tetrachloroethane	ND	0.58	mg/kg
Tetrachloroethene	ND	2.0	mg/kg
Toluene	ND	1.5	mg/kg
1,2,3-Trichlorobenzene	ND	0.58	mg/kg
1,2,4-Trichlorobenzene	ND	0.58	mg/kg
1,1,1-Trichloroethane	ND	1.2	mg/kg
1,1,2-Trichloroethane	ND	1.5	mg/kg
Trichloroethene	ND	2.9	mg/kg
1,2,3-Trichloropropane	ND	5.8	mg/kg
1,2,4-Trimethylbenzene	0.96 F	2.0	mg/kg
1,3,5-Trimethylbenzene	ND	0.87	mg/kg
Vinyl chloride	ND	2.6	mg/kg
o-Xylene	0.34 F	1.5	mg/kg
m-Xylene & p-Xylene	ND	0.87	mg/kg
1,2-Dibromo-3-chloropropane (DBCP)	ND	2.9	mg/kg
1,2-Dibromoethane (EDB)	ND	0.87	mg/kg

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
1,2-Dichloroethane-d4	85	(52 - 149)
4-Bromofluorobenzene	78	(65 - 135)
Toluene-d8	113	(65 - 135)
Dibromofluoromethane	122	(65 - 135)

**NOTE(S) :**

Results and reporting limits have been adjusted for dry weight.

F The analyte was identified but the value was below the RL and above the MDL.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

## GC/MS Semivolatiles

Lot-Sample #....: D8L120137-001    Work Order #....: CP913101    Matrix.....: WG  
 Date Sampled....: 12/10/98 15:30    Date Received...: 12/12/98  
 Prep Date.....: 12/17/98    Analysis Date...: 01/14/99  
 Prep Batch #....: 8349353    Analysis Time...: 05:56  
 Dilution Factor: 1  
 Method.....: CFR136A 625

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	6.4 J	10	ug/L
Acenaphthylene	ND	10	ug/L
Anthracene	1.6 J	10	ug/L
Benzidine	ND	100	ug/L
Benzo(a)anthracene	ND	10	ug/L
Benzo(b)fluoranthene	ND	10	ug/L
Benzo(ghi)perylene	ND	10	ug/L
Benzo(k)fluoranthene	ND	10	ug/L
Benzo(a)pyrene	ND	10	ug/L
4-Bromophenyl phenyl ether	ND	10	ug/L
Butyl benzyl phthalate	ND	10	ug/L
bis(2-Chloroethoxy) methane	ND	10	ug/L
bis(2-Chloroethyl) ether	ND	10	ug/L
bis(2-Chloroisopropyl) ether	ND	10	ug/L
4-Chloro-3-methylphenol	ND	10	ug/L
2-Chloronaphthalene	ND	10	ug/L
2-Chlorophenol	ND	10	ug/L
4-Chlorophenyl phenyl ether	ND	10	ug/L
Chrysene	ND	10	ug/L
Di-n-butyl phthalate	ND	10	ug/L
1,2-Dichlorobenzene	ND	10	ug/L
1,3-Dichlorobenzene	ND	10	ug/L
1,4-Dichlorobenzene	ND	10	ug/L
3,3'-Dichlorobenzidine	ND	50	ug/L
2,4-Dichlorophenol	ND	10	ug/L
Diethyl phthalate	ND	10	ug/L
2,4-Dimethylphenol	4.1 J	10	ug/L
Dimethyl phthalate	ND	10	ug/L
2,4-Dinitrophenol	ND	50	ug/L
2,4-Dinitrotoluene	ND	10	ug/L
2,6-Dinitrotoluene	ND	10	ug/L
Di-n-octyl phthalate	ND	10	ug/L
1,2-Diphenylhydrazine	ND	10	ug/L
bis(2-Ethylhexyl) phthalate	ND	10	ug/L

(Continued on next page)

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

## GC/MS Semivolatiles

Lot-Sample #....: D8L120137-001 Work Order #....: CP913101 Matrix.....: WG

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Fluoranthene	1.9 J	10	ug/L
Fluorene	7.8 J	10	ug/L
Hexachlorobenzene	ND	10	ug/L
Hexachlorobutadiene	ND	10	ug/L
Hexachlorocyclopentadiene	ND	50	ug/L
Hexachloroethane	ND	10	ug/L
Indeno (1,2,3-cd) pyrene	ND	10	ug/L
Isophorone	ND	10	ug/L
Naphthalene	140	10	ug/L
Nitrobenzene	ND	10	ug/L
2-Nitrophenol	ND	10	ug/L
4-Nitrophenol	ND	50	ug/L
N-Nitrosodimethylamine	ND	10	ug/L
N-Nitrosodi-n-propylamine	1.5 J	10	ug/L
N-Nitrosodiphenylamine	ND	10	ug/L
Pentachlorophenol	ND	50	ug/L
Phenanthrene	11	10	ug/L
Phenol	ND	10	ug/L
Pyrene	1.5 J	10	ug/L
1,2,4-Trichlorobenzene	ND	10	ug/L
2,4,6-Trichlorophenol	ND	10	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
2-Fluorophenol	81	(48 - 102)
Phenol-d5	91	(46 - 110)
Nitrobenzene-d5	76	(51 - 102)
2-Fluorobiphenyl	68	(39 - 91 )
2,4,6-Tribromophenol	98	(38 - 120)
Terphenyl-d14	54	(42 - 131)

**NOTE (S) :**

J Estimated result. Result is less than RL.

## PARSONS ENGINEERING SCIENCE, INC.

98POMP8-A

## GC/MS Semivolatiles

Lot-Sample #: D8L120137-001

Work Order #: CP913101

Matrix: WG

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Unknown #1	57-20-0	40	M	ug/L
Benzene, 1-ethyl-4-methyl-	622-96-8	200	M	ug/L
Benzene, 1,2,3-trimethyl- #1	526-73-8	89	M	ug/L
Benzene, 1,2,3-trimethyl- #2	526-73-8	250	M	ug/L
1,2,4-Trimethylbenzene	95-36-3	110	M	ug/L
Indane	496-11-7	47	M	ug/L
Benzene, 1-methyl-3-propyl-	1074-43-7	60	M	ug/L
Benzene, 1-ethyl-2,3-dimethyl-	933-98-2	91	M	ug/L
Unknown #2	57-20-0	64	M	ug/L
Unknown #3	57-20-0	61	M	ug/L
Unknown #4	57-20-0	49	M	ug/L
Benzene, 1,2,4,5-tetramethyl-	95-93-2	25	M	ug/L
Benzene, 1-methyl-2-(2-propeny	1587-04-8	58	M	ug/L
Naphthalene, 2-methyl-	91-57-6	160	M	ug/L
Naphthalene, 1-methyl-	90-12-0	120	M	ug/L
Benzeneacetic acid, .alpha.-me	492-37-5	26	M	ug/L
1(2H)-naphthalenone, 3,4-dihyd	529-34-0	27	M	ug/L
Naphthalene, 2,6-dimethyl-	581-42-0	35	M	ug/L
Naphthalene, 2,3-dimethyl-	581-40-8	49	M	ug/L
Naphthalene, 2,7-dimethyl-	582-16-1	36	M	ug/L

## NOTE (S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

## GC Volatiles

Lot-Sample #....: D8L120137-001    Work Order #....: CP913102    Matrix.....: WG  
Date Sampled....: 12/10/98 15:30    Date Received...: 12/12/98  
Prep Date.....: 12/17/98    Analysis Date...: 12/17/98  
Prep Batch #....: 8352219    Analysis Time...: 11:38  
Dilution Factor: 25  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	27	12	ug/L
Chlorobenzene	ND	12	ug/L
1,2-Dichlorobenzene	ND	12	ug/L
1,3-Dichlorobenzene	ND	12	ug/L
1,4-Dichlorobenzene	ND	12	ug/L
Ethylbenzene	220	12	ug/L
Methyl tert-butyl ether	ND	120	ug/L
Toluene	100	12	ug/L
Xylenes (total)	950	12	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	99	(82 - 112)

NOTE(S):

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

## GC Volatiles

Lot-Sample #....: D8L120137-001    Work Order #....: CP913104    Matrix.....: WG  
Date Sampled....: 12/10/98 15:30    Date Received...: 12/12/98  
Prep Date.....: 12/17/98    Analysis Date...: 12/17/98  
Prep Batch #....: 8352219    Analysis Time...: 11:38  
Dilution Factor: 25  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	25	12	ug/L
Chlorobenzene	ND	12	ug/L
1,2-Dichlorobenzene	ND	12	ug/L
1,3-Dichlorobenzene	ND	12	ug/L
1,4-Dichlorobenzene	ND	12	ug/L
Ethylbenzene	210	12	ug/L
Methyl tert-butyl ether	ND	120	ug/L
Toluene	60	12	ug/L
Xylenes (total)	920	12	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	152 *	(82 - 112)

## NOTE(S):

\* Surrogate recovery is outside stated control limits.

The surrogate recovery in the sample is outside control limits due to confirmed matrix effect.

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSW1

## GC Volatiles

Lot-Sample #....: D8L120137-002    Work Order #....: CP91P101    Matrix.....: WG  
Date Sampled....: 12/11/98 08:30    Date Received...: 12/12/98  
Prep Date.....: 12/17/98    Analysis Date...: 12/17/98  
Prep Batch #....: 8352219    Analysis Time...: 12:13  
Dilution Factor: 1

Method.....: CFR136A 602

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Benzene	ND	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	ND	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	ND	0.50	ug/L
Xylenes (total)	ND	0.50	ug/L

<u>SURROGATE</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>
a,a,a-Trifluorotoluene (TFT)	95	(82 - 112)



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSW2

## GC Volatiles

Lot-Sample #....: D8L120137-003    Work Order #....: CP91X101    Matrix.....: WG  
Date Sampled....: 12/11/98 08:40    Date Received...: 12/12/98  
Prep Date.....: 12/17/98    Analysis Date...: 12/17/98  
Prep Batch #....: 8352219    Analysis Time...: 12:49  
Dilution Factor: 1  
Method.....: CFR136A 602

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Benzene	ND	0.50	ug/L
Chlorobenzene	ND	0.50	ug/L
1,2-Dichlorobenzene	ND	0.50	ug/L
1,3-Dichlorobenzene	ND	0.50	ug/L
1,4-Dichlorobenzene	ND	0.50	ug/L
Ethylbenzene	ND	0.50	ug/L
Methyl tert-butyl ether	ND	5.0	ug/L
Toluene	ND	0.50	ug/L
Xylenes (total)	ND	0.50	ug/L

<u>SURROGATE</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>
a,a,a-Trifluorotoluene (TFT)	95	(82 - 112)

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

HPLC

Lot-Sample #....: D8L120137-001 Work Order #....: CP913103 Matrix.....: WG  
 Date Sampled....: 12/10/98 15:30 Date Received...: 12/12/98  
 Prep Date.....: 12/16/98 Analysis Date...: 01/12/99  
 Prep Batch #....: 8350102 Analysis Time...: 17:42  
 Dilution Factor: 5  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	5.0	ug/L
Acenaphthylene	ND	5.0	ug/L
Anthracene	3.5	0.50	ug/L
Benzo (a) anthracene	ND	0.65	ug/L
Benzo (a) pyrene	1.1 F	1.2	ug/L
Benzo (b) fluoranthene	1.0	0.90	ug/L
Benzo (ghi) perylene	ND	1.0	ug/L
Benzo (k) fluoranthene	0.70 F	0.85	ug/L
Chrysene	ND	1.0	ug/L
Dibenzo (a,h) anthracene	ND	1.5	ug/L
Fluoranthene	20	1.0	ug/L
Fluorene	ND	1.0	ug/L
Indeno (1,2,3-cd) pyrene	ND	2.2	ug/L
Naphthalene	180	5.0	ug/L
Phenanthrene	27	1.0	ug/L
Pyrene	ND	1.0	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
Terphenyl-d14	0.0 DIL, *	(25 - 157)

NOTE (S) :

DIL The concentration is estimated or not reported due to dilution or the presence of interfering analytes.

\* Surrogate recovery is outside stated control limits.

F The analyte was identified but the value was below the RL and above the MDL.

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

## HPLC

Lot-Sample #....: D8L120137-001    Work Order #....: CP913105    Matrix.....: WG  
 Date Sampled....: 12/10/98 15:30    Date Received...: 12/12/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/12/99  
 Prep Batch #....: 8350102    Analysis Time...: 17:42  
 Dilution Factor: 5  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	5.0	ug/L
Acenaphthylene	ND	5.0	ug/L
Anthracene	2.5	0.50	ug/L
Benzo (a) anthracene	ND	0.65	ug/L
Benzo (a) pyrene	1.3	1.2	ug/L
Benzo (b) fluoranthene	1.5	0.90	ug/L
Benzo (ghi) perylene	ND	1.0	ug/L
Benzo (k) fluoranthene	0.53 F	0.85	ug/L
Chrysene	ND	1.0	ug/L
Dibenzo (a,h) anthracene	ND	1.5	ug/L
Fluoranthene	8.6	1.0	ug/L
Fluorene	ND	1.0	ug/L
Indeno (1,2,3-cd) pyrene	ND	2.2	ug/L
Naphthalene	190	5.0	ug/L
Phenanthrene	24	1.0	ug/L
Pyrene	ND	1.0	ug/L
SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS	
Terphenyl-d14	0.0 DIL, *	(25 - 157)	

NOTE (S) :

DIL The concentration is estimated or not reported due to dilution or the presence of interfering analytes.

\* Surrogate recovery is outside stated control limits.

F The analyte was identified but the value was below the RL and above the MDL.

2C

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB3-12

General Chemistry

Lot-Sample #....: D8L120137-005    Work Order #....: CP934    Matrix.....: SO  
Date Sampled....: 12/11/98 14:30    Date Received...: 12/12/98  
% Moisture.....: 8.1

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Percent Moisture	8.1	0.10	%	MCAWW 160.3 MOD	12/28-01/22/99	8363185
		Dilution Factor: 1		Analysis Time...: 00:00		

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB4-12

General Chemistry

Lot-Sample #....: D8L120137-006    Work Order #....: CP935  
Date Sampled....: 12/11/98 11:00    Date Received...: 12/12/98  
% Moisture.....: 14

Matrix.....: SO

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Percent Moisture	13.8	0.10	%	MCAWW 160.3 MOD	12/28-12/29/98	8363185
		Dilution Factor: 1		Analysis Time...: 00:00		

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB1-9.5

General Chemistry

Lot-Sample #....: D8L120137-007    Work Order #....: CP936    Matrix.....: SO  
 Date Sampled....: 12/11/98 09:40    Date Received...: 12/12/98  
 % Moisture.....: 11

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION- ANALYSIS DATE	PREP BATCH #
Percent Moisture	10.9	0.50	%	ASTM D 2216-90	01/05-01/06/99	9005265
		Dilution Factor: 1		Analysis Time...: 00:00		
Total Recoverable Petroleum Hydrocarbons	ND	11.2	mg/kg	MCAWW 418.1	01/08-01/13/99	9011142
		Dilution Factor: 1		Analysis Time...: 15:00		

NOTE(S):

RL Reporting Limit

Results and reporting limits have been adjusted for dry weight.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB6-12

General Chemistry

Lot-Sample #....: D8L120137-008    Work Order #....: CP937    Matrix.....: SO  
 Date Sampled....: 12/11/98 09:00    Date Received...: 12/12/98  
 % Moisture.....: 16

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION- ANALYSIS DATE	PREP BATCH #
Percent Moisture	15.8	0.10	%	MCAWW 160.3 MOD	12/28-01/22/99	8363185
		Dilution Factor: 1		Analysis Time...: 00:00		
Total Organic Carbon ND		2000	mg/kg	SW846 9060	12/21-12/22/98	8356345
		Dilution Factor: 1		Analysis Time...: 11:00		

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB5-12

General Chemistry

Lot-Sample #....: D8L120137-009    Work Order #....: CP938    Matrix.....: SO  
 Date Sampled....: 12/11/98 08:15    Date Received...: 12/12/98  
 % Moisture.....: 16

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION- ANALYSIS DATE	PREP BATCH #
Percent Moisture	16.4	0.10	%	MCAWW 160.3 MOD	12/28-01/22/99	8363185
		Dilution Factor: 1		Analysis Time...: 00:00		
Total Organic Carbon ND		2000	mg/kg	SW846 9060	12/21-12/22/98	8356345
		Dilution Factor: 1		Analysis Time...: 11:00		



Laboratory Non-Conformance  
Memo (NCM)

NCM Log Number 14929

QUA-4187	Project ID/Client D&L 120137 #5,6	Sample Numbers	NCM Initiated by/Date MBA 1/2/99	Project Manager E. Lariviere
Analyst/Team M. Hoffman				

Tests 8260-AFCEE Med. Level Soils.

Analytical Area (check appropriate box)

<input type="checkbox"/> Sample control	<input type="checkbox"/> Organic preparation	<input type="checkbox"/> Inorganic preparation	<input type="checkbox"/> GC	<input type="checkbox"/> HPLC	<input checked="" type="checkbox"/> GC/MS	<input type="checkbox"/> Wet chemistry
<input type="checkbox"/> Metals	<input type="checkbox"/> Reporting	<input type="checkbox"/> Data review	<input type="checkbox"/> Radiochemistry			

Non-Conformance (check appropriate box) To be completed by analyst

Holding Time Violation (exceeded by \_\_\_\_\_ days)

Category I: Laboratory Independent

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

Category II: Laboratory Dependent

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required)

Category III: Analysis Reruns (QA/QC)

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

Category IV: Analysis Reruns (Confirmation)

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required)

Quality Assurance/Quality Control

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

Incorrect or Incomplete Client Deliverable

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

Reported Detection Limits Elevated Due to:

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required)

Miscellaneous

- ☐ 27. Instrument Tag-out
- ☐ 28. Other (explanation required)

Notification (check appropriate box) To be completed by project manager

☒ Required ☐ Not Required

Client notified by - Name Ellen LaRiviere	Date	<input type="checkbox"/> In writing	<input type="checkbox"/> By telephone	<input type="checkbox"/> By facsimile	<input type="checkbox"/> Other (explain)
Client's name and response John Heils	<input checked="" type="checkbox"/> Process "as is"	<input type="checkbox"/> On hold until	<input type="checkbox"/> Re-sample	<input type="checkbox"/> Other (explain)	
Project manager signature Ellen LaRiviere	Date 1/21/99	46			

**Laboratory Non-Conformance  
Memo (NCM)**

QUA-4187

NCM Log Number

14929

**Corrective Action** (To be completed and reviewed by all associates involved)

Problem Description/Root Cause

The recovery for dichlorodifluoromethane is 42% in the LCS and 43% in the LCSD. The limits are 65-135%. The cause is that we have never recovered more than 50% for this compound in med. level soils due to the extraction.

Author's initials and date

MA 1/21/99

Corrective Actions (Short Term)

Report the data with an anomaly.

Author's initials and date

MA 1/21/99

Corrective Actions to Prevent Reoccurrence (Long Term)

Change the limits for this compound for medium level soils.

Corrective Action approved by (Supervisor/Group Leader) and date

Wm. Chas. Jr.

Additional Comments

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

**Quality Assurance Review** (To be completed by a QA associate)

Log ID

☐

Anomaly

☐

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐ Further action required

☐ Further action assigned to

QA signature

Date

**Corrective Action Verification** (To be completed by a QA associate)

☐ Verification not required or requested

☐

Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐ Cannot verify (specify reason) \_\_\_\_\_

Verified by

Date

**Nonconformance Memo Closure**

signature

Date

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

**Laboratory Non-Conformance  
Memo (NCM)**

8349353

QUA-4187	B8L030177-01 - WMX	NCM Log Number <b>15694</b>	
Project ID/Client D8L120137-01 D8L110138-01 } PARSONS	Sample Numbers	NCM Initiated by/Date F 1-15-99	Project Manager LA RIVICAR D. ARZZO

Analyst/Team

R/BNA

Tests

625

**Analytical Area (check appropriate box)**

- |                                         |                                              |                                                |                                         |                               |                                           |                                        |
|-----------------------------------------|----------------------------------------------|------------------------------------------------|-----------------------------------------|-------------------------------|-------------------------------------------|----------------------------------------|
| <input type="checkbox"/> Sample control | <input type="checkbox"/> Organic preparation | <input type="checkbox"/> Inorganic preparation | <input type="checkbox"/> GC             | <input type="checkbox"/> HPLC | <input checked="" type="checkbox"/> GC/MS | <input type="checkbox"/> Wet chemistry |
| <input type="checkbox"/> Metals         | <input type="checkbox"/> Reporting           | <input type="checkbox"/> Data review           | <input type="checkbox"/> Radiochemistry | <input type="checkbox"/>      | <input type="checkbox"/>                  | <input type="checkbox"/>               |

**Non-Conformance (check appropriate box) To be completed by analyst**

**Holding Time Violation (exceeded by \_\_\_\_\_ days)**

**Category I: Laboratory Independent**

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

**Category II: Laboratory Dependent**

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required)

**Category III: Analysis Reruns (QA/QC)**

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

**Category IV: Analysis Reruns (Confirmation)**

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required)

**Quality Assurance/Quality Control**

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

**Incorrect or Incomplete Client Deliverable**

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

**Reported Detection Limits Elevated Due to:**

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required)

**Miscellaneous**

- ☐ 27. Instrument Tag-out
- ☒ 28. Other (explanation required)

EXPIRED LCS STANDARD (V11292)  
USED BECAUSE LAB RAN OUT  
OF STANDARD, AND THE SAMPLES  
WOULD HAVE EXPIRED PRIOR TO  
RECEIPT OF A REPLACEMENT STANDARD.

**Notification (check appropriate box) To be completed by project manager**

☐ Required ☐ Not Required

Notification by - Name

Date

Michael Leusch 1/18/99

☒ In writing ☐ By telephone ☐ By facsimile ☐ Other (explain)

Analyst's name and response

☐ Process "as is" ☐ On hold until ☐ Re-sample ☐ Other (explain)

Project manager signature

*[Signature]*

Date

1-18-99

**Laboratory Non-Conformance  
Memo (NCM)**

OIA-4187

NCM Log Number

15694

**Corrective Action (To be completed and reviewed by all associates involved)**

**Description/Root Cause**

SEE ATTACHMENT

Author's initials and date

K 1-15-99

**Corrective Actions (Short Term)**

THE SAMPLES HAVE EXPIRED. NOTIFY CLIENT PRIOR TO TAKING COLLECTIVE ACTION.

Author's initials and date

K 1-15-99

**Corrective Actions to Prevent Recurrence (Long Term)**

ENSURE THAT STANDARDS ARE REPLACED PRIOR TO COMPLETE DEPLETION.

Corrective Action approved by (Supervisor/Group Leader) and date

K 1-15-99

**Additional Comments**

**Corrective Action to be completed by (if other than Supervisor/Group Leader)**

**Date Corrective Action is to be completed**

**Quality Assurance Review (To be completed by a QA associate)**

**Log ID**

☐

Anomaly

☒

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐ Further action required

☐ Further action assigned to

**QA signature**

Thom Krumm

**Date**

1/19/99

**Corrective Action Verification (To be completed by a QA associate)**

☐ Verification not required or requested

☐

Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐ Cannot verify (specify reason) \_\_\_\_\_

**Verified by**

**Date**

**Signature**

Thom Krumm

**Date**

1/19/99

**Nonconformance Memo Closure**

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

**Laboratory Non-Conformance  
Memo (NCM)**

QUA-4187	D8L100136-001, MS, SD	NCM Log Number	15897
Project ID/Client	D8L110138-001, 003	Sample Numbers	
8350102	D8L120137-001	NCM Initiated by/Date	1/18/99
Analyst/Team		Project Manager	E. La Riviere

Tests  
**8310 PAH**

Analytical Area (check appropriate box)

<input type="checkbox"/> Sample control	<input type="checkbox"/> Organic preparation	<input type="checkbox"/> Inorganic preparation	<input type="checkbox"/> GC	<input checked="" type="checkbox"/> HPLC	<input type="checkbox"/> GC/MS	<input type="checkbox"/> Wet chemistry
<input type="checkbox"/> Metals	<input type="checkbox"/> Reporting	<input type="checkbox"/> Data review	<input type="checkbox"/> Radiochemistry	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Non-Conformance (check appropriate box) To be completed by analyst

Holding Time Violation (exceeded by \_\_\_\_\_ days)

Category I: Laboratory Independent

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

Category II: Laboratory Dependent

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required) \_\_\_\_\_

Category III: Analysis Reruns (QA/QC)

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

Category IV: Analysis Reruns (Confirmation)

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required) \_\_\_\_\_

Quality Assurance/Quality Control

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

Incorrect or Incomplete Client Deliverable

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

Reported Detection Limits Elevated Due to:

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required) \_\_\_\_\_

Miscellaneous

- ☐ 27. Instrument Tag-out
- ☐ 28. Other (explanation required) \_\_\_\_\_

Notification (check appropriate box) To be completed by project manager

☐ Required ☒ Not Required

Client notified by - Name	Date	<input type="checkbox"/> In writing	<input type="checkbox"/> By telephone	<input type="checkbox"/> By facsimile	<input type="checkbox"/> Other (explain) _____
Client's name and response	<input type="checkbox"/> Process "as is"	<input type="checkbox"/> On hold until _____	<input type="checkbox"/> Re-sample	<input type="checkbox"/> Other (explain) _____	
Project manager signature	Date				1/18/99

**Laboratory Non-Conformance  
Memo (NCM)**

QUA-4187

NCM Log Number

15897

**Corrective Action (To be completed and reviewed by all associates involved)**

Problem Description/Root Cause

recoveries for dibenzo (a,h) anthracene are high for both LCS (109% max is 100% and LCSD (119% max is 103%)

Author's initials and date

DOX 11/18/99

**Corrective Actions (Short Term)**

there are no hits for dibenzo (a,h) anthracene in samples

Author's initials and date

DOX 11/18/99

**Corrective Actions to Prevent Reoccurrence (Long Term)**

Corrective Action approved by (Supervisor/Group Leader) and date

**Additional Comments**

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

**Quality Assurance Review (To be completed by a QA associate)**

Log ID

☐

Anomaly

☒

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐

Further action required

☐

Further action assigned to

QA signature

Thomas Khumwan

Date

1/19/99

**Corrective Action Verification (To be completed by a QA associate)**

☐

Verification not required or requested

☐

Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐

Cannot verify (specify reason)

Verified by

Date

**Nonconformance Memo Closure**

QA signature

Thomas Khumwan

Date

1/19/99

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

Lot #: D8L120137 Date/Time Received: 12/29/8 0900

Company Name & Sampling Site: Perigon

\*Cooler #(s): 1

Temperatures: 2.7

Unpacking & Labeling Check Points:

- | Y/A | Yes                                 | No                                  |                                                       |                          |           |
|-----|-------------------------------------|-------------------------------------|-------------------------------------------------------|--------------------------|-----------|
|     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 1. Radiation checked, record if reading > 0.5 mR/hr.  | ( <u>        </u> mR/hr) | <u>PK</u> |
|     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 2. Cooler seals intact.                               |                          |           |
|     | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 3. Chain of custody present.                          |                          |           |
|     | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 4. Bottles broken and/or are leaking, comment if yes. |                          |           |

PHOTOGRAPH BROKEN BOTTLES

- |  |                                     |                                     |                                                                                                |  |  |
|--|-------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------|--|--|
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 5. Containers labeled, comment if no.                                                          |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 6. pH of all samples checked and meet requirements, note exceptions.                           |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 7. Chain of custody includes "received by" and "relinquished" by signatures, dates, and times. |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 8. Receipt date(s) > 48 hours past the collection date(s)? If yes, notify PA/PM.               |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 9. Chain of custody agrees with bottle count, comment if no.                                   |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 10. Chain of custody agrees with labels, comment if no.                                        |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 11. VOA samples filled completely, comment if no.                                              |  |  |
|  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 12. VOA bottles preserved, check for labels.                                                   |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 13. Did samples require preservation with sodium thiosulfate?                                  |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 14. If yes to #12, did the samples contain residual chlorine?                                  |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 15. Sediment present in "D," dissolved, bottles.                                               |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 16. Are analyses with short holding times requested?                                           |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 17. Is extra sample volume provided for MS, MSD or matrix duplicates?                          |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 18. Multiphase samples present? If yes, comment below.                                         |  |  |
|  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 19. Any subsampling for volatiles? If yes, list samples.                                       |  |  |

PHOTOGRAPH MULTIPHASE SAMPLES

- |  |                          |                          |                                                                  |  |  |
|--|--------------------------|--------------------------|------------------------------------------------------------------|--|--|
|  | <input type="checkbox"/> | <input type="checkbox"/> | 20. Clear picture taken, labeled, and stapled to project folder. |  |  |
|  | <input type="checkbox"/> | <input type="checkbox"/> | 21. Subcontract CCC signed and sent with samples to bottle prep? |  |  |
|  | <input type="checkbox"/> | <input type="checkbox"/> | 22. Was sample labeling double checked?                          |  |  |

Comments: Include action taken to resolve discrepancies/problems. Include a hard copy of e-mail or use extra paper if more space is needed.

Initials: \_\_\_\_\_

# Chain of Custody Record

D8L120137

27014



QUA-4124 0797

Client <b>Parsens Eng. Science, Inc.</b>	Project Manager <b>John Hicks</b>	Date <b>12/11/98</b>	Chain of Custody Number <b>19803</b>
Address <b>1700 Broadway Suite 900</b>	Telephone Number (Area Code)/Fax Number <b>303-831-8100</b>	Lab Number	
City <b>Denver</b>	Site Contact <b>T. Drago</b>	Page <b>1</b>	of <b>1</b>
Project Name <b>AFEE - RBCA Inves. System</b>	Lab Contact <b>Ellen</b>	Special Instructions/ Conditions of Receipt	
Contract/Purchase Order/Quote No.	Carrier/Waybill Number		

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix					Containers & Preservatives					Analysis (Attach list if more space is needed)									
			Aqueous	Sol.	Soil	Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc	NaOH	8310 SVOL	625 SVOL	602 VOC (MS)	602 VOC (MSD)	8270 SVOL	8260 VOC	E481 TPT	9060 TOC	Special Instructions/ Conditions of Receipt	
1 98PO5W2-A	12-10-98	15:30	X						X				X	X								
2 98PO5W1	12-11-98	8:30	X						X				X	X							9 VOAS (35 SETS OF 3) PLEASE HOLD FOR ANALYSIS ENCLOSED IN ONE UGT	
3 98PO5W2	12-11-98	8:40	X										X	X								
4 98PO5W8-18 (FREE PRODUCT)	12-11-98	10:20	X										X	X							These samples were lost by Quanterra	
5 98PO5W4-12	12-11-98	14:30			X																	
6 98PO5W4-12	12-11-98	11:00			X																selected for 8260 TOC	
7 98PO5W1-9.5	12-11-98	9:40			X																	
8 98PO5W6-12	12-11-98	9:00			X																	
9 98PO5W5-12	12-11-98	8:15			X																	
10 TEMP ISLANK																						
11 TRIP BLANK																						
12 TRIP BLANK																						

Possible Hazard Identification	Sample Disposal	QC Requirements (Specify)
<input type="checkbox"/> Non-Hazard <input type="checkbox"/> Flammable <input type="checkbox"/> Skin Irritant <input type="checkbox"/> Poison B <input checked="" type="checkbox"/> Unknown	<input type="checkbox"/> Return To Client <input type="checkbox"/> Disposal By Lab	(A lab may be assessed if samples are retained longer than 3 months) Archive For <b>3</b> Months Please hold (archive) free product sample!!! Requested By <b>John Hicks</b> Received By <b>John Hicks</b> Date <b>12/11/98</b> Time <b>1900</b> Date <b>12/11/98</b> Time <b>0900</b> Date <b>12/11/98</b> Time <b>0900</b> Date <b>12/11/98</b> Time <b>0900</b>

Comments  
4 Please run 10 largest non-target peaks for 625 SVOL analysis!!!

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy



Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

## ANALYTICAL REPORT

Pope AFB  
Lot #: D8L110138

John Hicks  
Parsons Engineering Services

QUANTERRA INCORPORATED



Ellen La Riviere  
Project Manager

January 29, 1999

# Table Of Contents

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Section	Report Contents	Number of Pages
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### Standard Deliverables

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- Executive Summary – Detection
- Analytical Methods Summary
- Method/Analyst Summary
- Lot Sample Summary
- Analytical Results by Sample
- QC Data Association Summary
- Chain-of-Custody

### Supporting Documentation

[Please Note: A one-page "Description of Supporting Documentation" is provided in the Supporting Documentation section(s).]

#### B. • Volatile GC/MS

#### C. • Semivolatile GC/MS

#### D. • Volatile GC

#### E. • Semivolatile GC

#### F. • LC/MS or HPLC

#### G. • Metals

#### H. • General Chemistry

#### I. • Subcontracted Data

Total # Pages in this Package

# Project Narrative

(D8L110138)

## GC/MS Volatiles

Due to the concentration of target compounds present, sample D8L110138-004 was extracted as a medium level soil. Due to the extraction procedure, dichlorodifluoromethane was recovered below the lower control limits in the LCS/LCSD associated with the samples. The client was contacted on December 21, 1998. Because these were not compounds of concern for the site, no further action was required.

## GC/MS Semi-Volatiles

Due to laboratory error, sample D8L110138-004 was never extracted for Method 8270. The client was contacted on January 19, 1999 and requested the laboratory not perform the extraction outside of holding time. Therefore, the Method 8270 analyses were canceled for this sample.

The extraction lab ran out of all analyte spike, and it was not possible to obtain a new supply prior to sample expiration. Therefore, an expired all analyte spike standard (V11292) was used to prepare the LCS/LCSD and MS/MSD for QC Batch 8349353. The expired standard was re-verified, but the re-verification showed that benzidine and 3,3'-dichlorobenzidine had degraded and were no longer present in the expired standard.

The MS is the primary control sample for Method 625. The LCS is used as a backup for the MS.

As expected, Benzidine and 3,3'-Dichlorobenzidine were not detected in the LCS/LCSD. Since it was shown that Benzidine and 3,3'-Dichlorobenzidine were not present in the spiking standard, corrective action was not initiated when these compounds were not found in the LCS/LCSD.

The RPD for diethylphthalate exceeded the control limit in the LCS/LCSD. This was unrelated to the use of the expired standard. However, Method 625 has no RPD criteria because it does not require the analysis of a LCSD, and diethylphthalate was not detected in any sample above the reporting limit. Therefore, no corrective was taken for this problem.

An additional problem for Lot D8L110138 was poor recovery of hexachlorocyclopentadiene. Hexachlorocyclopentadiene was out of control for the LCS with a recovery of 0% (the lower control limit for this compound is 2.0%). Hexachlorocyclopentadiene was in control for the LCSD with a recovery of 2.8%. This was unrelated to the use of the expired standard. According to Method 625, hexachlorocyclopentadiene is not listed as a control analyte for a LCS. Therefore, no corrective was taken for this problem.

## Polynuclear Aromatic Hydrocarbons

Dibenzo(a,h)anthracene was recovered above the upper control limits in the LCS/LCSD associated with the samples in this project. Because this would indicate a high bias to the data, and this compound was not detected in the samples, no further action was required.

## **Methane**

Samples D8L110138-001 and -002 were analyzed for Methane by the RSK-175 method by Quanterra's Austin laboratory. Sample D8L110138-001 was initially analyzed undiluted. Methane was detected at a concentration above the linear calibration range of the instrument and has been reported with an "E flag." The second vial of the sample was reanalyzed, but did not have comparable concentrations of methane. Both sets of data have been reported.

# EXECUTIVE SUMMARY - Detection Highlights

D8L110138

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
98PCMP8-B 12/10/98 09:20 001				
Benzene	4.2 J	5.0	ug/L	CFR136A 602
Benzene	4.2 J	5.0	ug/L	CFR136A 602
Benzene	3.9 J	5.0	ug/L	CFR136A 602
Chlorobenzene	5.8	5.0	ug/L	CFR136A 602
Chlorobenzene	5.8	5.0	ug/L	CFR136A 602
Chlorobenzene	7.2	5.0	ug/L	CFR136A 602
1,2-Dichlorobenzene	6.9	5.0	ug/L	CFR136A 602
1,2-Dichlorobenzene	6.9	5.0	ug/L	CFR136A 602
1,2-Dichlorobenzene	9.3	5.0	ug/L	CFR136A 602
1,3-Dichlorobenzene	8.0	5.0	ug/L	CFR136A 602
1,3-Dichlorobenzene	8.0	5.0	ug/L	CFR136A 602
1,3-Dichlorobenzene	9.4	5.0	ug/L	CFR136A 602
1,4-Dichlorobenzene	13	5.0	ug/L	CFR136A 602
1,4-Dichlorobenzene	13	5.0	ug/L	CFR136A 602
1,4-Dichlorobenzene	29	5.0	ug/L	CFR136A 602
Ethylbenzene	16	5.0	ug/L	CFR136A 602
Ethylbenzene	16	5.0	ug/L	CFR136A 602
Ethylbenzene	17	5.0	ug/L	CFR136A 602
Toluene	8.7 B	5.0	ug/L	CFR136A 602
Toluene	8.7 B	5.0	ug/L	CFR136A 602
Toluene	8.9 B	5.0	ug/L	CFR136A 602
Xylenes (total)	61	5.0	ug/L	CFR136A 602
Xylenes (total)	61	5.0	ug/L	CFR136A 602
Xylenes (total)	68	5.0	ug/L	CFR136A 602
Methane	140 B, E	0.50	ug/L	EPA-9 RSK-175
Methane	12	0.50	ug/L	EPA-9 RSK-175
Anthracene	1.1	0.50	ug/L	SW846 8310
Anthracene	1.1	0.50	ug/L	SW846 8310
Anthracene	1.0	0.50	ug/L	SW846 8310
Naphthalene	120	5.0	ug/L	SW846 8310
Naphthalene	120	5.0	ug/L	SW846 8310
Naphthalene	120	5.0	ug/L	SW846 8310
Phenanthrene	9.7	1.0	ug/L	SW846 8310
Phenanthrene	9.7	1.0	ug/L	SW846 8310
Phenanthrene	7.0	1.0	ug/L	SW846 8310
Anthracene	1.1 J	10	ug/L	CFR136A 625
Naphthalene	110	10	ug/L	CFR136A 625
Phenanthrene	7.6 J	10	ug/L	CFR136A 625

(Continued on next page)

# EXECUTIVE SUMMARY - Detection Highlights

D8L110138

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
98PCMP8-A 12/10/98 15:30 002				
Methane	270 E	0.50	ug/L	EPA-9 RSK-175
Methane	3000 B,D	25	ug/L	EPA-9 RSK-175
98PCMW8-11 12/09/98 14:40 003				
Benzene	32	5.0	ug/L	CFR136A 602
Benzene	30	5.0	ug/L	CFR136A 602
Benzene	30	5.0	ug/L	CFR136A 602
Ethylbenzene	15	5.0	ug/L	CFR136A 602
Ethylbenzene	13	5.0	ug/L	CFR136A 602
Ethylbenzene	13	5.0	ug/L	CFR136A 602
Xylenes (total)	53	5.0	ug/L	CFR136A 602
Xylenes (total)	44	5.0	ug/L	CFR136A 602
Xylenes (total)	44	5.0	ug/L	CFR136A 602
Anthracene	0.43	0.10	ug/L	SW846 8310
Anthracene	0.43	0.10	ug/L	SW846 8310
Anthracene	0.47	0.10	ug/L	SW846 8310
Benzo(a)pyrene	0.082 F	0.23	ug/L	SW846 8310
Benzo(a)pyrene	0.082 F	0.23	ug/L	SW846 8310
Benzo(a)pyrene	0.088 F	0.23	ug/L	SW846 8310
Benzo(b)fluoranthene	0.21	0.18	ug/L	SW846 8310
Benzo(b)fluoranthene	0.21	0.18	ug/L	SW846 8310
Benzo(b)fluoranthene	0.76	0.18	ug/L	SW846 8310
Fluoranthene	2.1	0.20	ug/L	SW846 8310
Fluoranthene	2.1	0.20	ug/L	SW846 8310
Fluoranthene	0.79	0.20	ug/L	SW846 8310
Fluorene	5.0	0.20	ug/L	SW846 8310
Fluorene	5.0	0.20	ug/L	SW846 8310
Fluorene	2.1	0.20	ug/L	SW846 8310
Naphthalene	20	1.0	ug/L	SW846 8310
Naphthalene	20	1.0	ug/L	SW846 8310
Naphthalene	12	1.0	ug/L	SW846 8310
Phenanthrene	0.88	0.20	ug/L	SW846 8310
Phenanthrene	0.88	0.20	ug/L	SW846 8310
Phenanthrene	2.3	0.20	ug/L	SW846 8310
98POSB2-12 12/10/98 11:30 004				
n-Butylbenzene	7.9	5.3	mg/kg	SW846 8260A
sec-Butylbenzene	3.9 F	7.4	mg/kg	SW846 8260A
Ethylbenzene	6.0	3.2	mg/kg	SW846 8260A
Isopropylbenzene	3.5 F	8.5	mg/kg	SW846 8260A
Naphthalene	22	5.3	mg/kg	SW846 8260A

(Continued on next page)

# EXECUTIVE SUMMARY - Detection Highlights

D8L110138

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>ANALYTICAL METHOD</u>
98POSB2-12 12/10/98 11:30 004				
n-Propylbenzene	4.4	2.1	mg/kg	SW846 8260A
1,2,4-Trimethylbenzene	47	7.4	mg/kg	SW846 8260A
1,3,5-Trimethylbenzene	25	3.2	mg/kg	SW846 8260A
o-Xylene	5.6	5.3	mg/kg	SW846 8260A
m-Xylene & p-Xylene	42	3.2	mg/kg	SW846 8260A
Percent Moisture	5.4	0.10	%	MCAWW 160.3 MOD
TRIPBLANK 12/10/98 005				
Methylene chloride	1.0 F,B	5.0	ug/L	SW846 8260A

# ANALYTICAL METHODS SUMMARY

D8L110138

<u>PARAMETER</u>	<u>ANALYTICAL METHOD</u>
Base/Neutrals and Acids	CFR136A 625
Dissolved Gasses in Water	EPA-9 RSK-175
Nitrate as N	SW846 9056
Percent Moisture	MCAWW 160.3 MOD
Polynuclear Aromatic Hydrocarbons by HPLC	SW846 8310
Purgeable Aromatics	CFR136A 602
Volatile Organics by GC/MS	SW846 8260A

## References:

- CFR136A "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.
- EPA-9 Sample Prep and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, RSKSOP-175, REV. 0, 8/11/94, USEPA Research Lab
- MCAWW "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.
- SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.



## METHOD / ANALYST SUMMARY

D8L110138

<u>ANALYTICAL METHOD</u>	<u>ANALYST</u>	<u>ANALYST ID</u>
CFR136A 602	Dustin Harding	001807
CFR136A 625	Robert P. Guthrie	001593
EPA-9 RSK-175	Brook Derenzy	005830
MCAWW 160.3 MOD	Andrea Sporleder	001971
SW846 8260A	Mike G. Hoffman	001880
SW846 8310	Dane Rodgers	007407
SW846 9056	Patty Jungk	002008

### References:

CFR136A "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

EPA-9 Sample Prep and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique, RSKSOP-175, REV. 0, 8/11/94, USEPA Research Lab

MCAWW "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.

SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

## SAMPLE SUMMARY

D8L110138

WO #	SAMPLE#	CLIENT SAMPLE ID	DATE	TIME
CP7LP	001	98POMP8-B	12/10/98	09:20
CP7LQ	002	98POMP8-A	12/10/98	15:30
CP7LV	003	98POMW8-11	12/09/98	14:40
CP7LW	004	98POSB2-12	12/10/98	11:30
CP7LX	005	TRIPBLANK	12/10/98	

### NOTE (S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB2-12

## GC/MS Volatiles

Lot-Sample #....: D8L110138-004    Work Order #....: CP7LW101    Matrix.....: SO  
 Date Sampled....: 12/10/98 11:30    Date Received...: 12/11/98  
 Prep Date.....: 12/14/98    Analysis Date...: 12/16/98  
 Prep Batch #....: 9019272    Analysis Time...: 21:10  
 Dilution Factor: 20  
 % Moisture.....: 5.4    Method.....: SW846 8260A

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	ND	2.1	mg/kg
Bromobenzene	ND	2.1	mg/kg
Bromochloromethane	ND	2.1	mg/kg
Bromodichloromethane	ND	4.2	mg/kg
Bromoform	ND	6.3	mg/kg
Bromomethane	ND	5.3	mg/kg
n-Butylbenzene	7.9	5.3	mg/kg
sec-Butylbenzene	3.9 F	7.4	mg/kg
tert-Butylbenzene	ND	7.4	mg/kg
Carbon tetrachloride	ND	11	mg/kg
Chlorobenzene	ND	2.1	mg/kg
Chlorodibromomethane	ND	3.2	mg/kg
Chloroethane	ND	5.3	mg/kg
Chloroform	ND	2.1	mg/kg
1-Chlorohexane	ND	3.2	mg/kg
Chloromethane	ND	7.4	mg/kg
2-Chlorotoluene	ND	2.1	mg/kg
4-Chlorotoluene	ND	3.2	mg/kg
Dibromomethane	ND	11	mg/kg
1,2-Dichlorobenzene	ND	2.1	mg/kg
1,3-Dichlorobenzene	ND	6.3	mg/kg
1,4-Dichlorobenzene	ND	2.1	mg/kg
Dichlorodifluoromethane	ND	5.3	mg/kg
1,1-Dichloroethane	ND	2.1	mg/kg
1,2-Dichloroethane	ND	3.2	mg/kg
1,1-Dichloroethene	ND	6.3	mg/kg
cis-1,2-Dichloroethene	ND	6.3	mg/kg
trans-1,2-Dichloroethene	ND	3.2	mg/kg
1,2-Dichloropropane	ND	2.1	mg/kg
1,3-Dichloropropane	ND	2.1	mg/kg
2,2-Dichloropropane	ND	21	mg/kg
1,1-Dichloropropene	ND	5.3	mg/kg
cis-1,3-Dichloropropene	ND	5.3	mg/kg
trans-1,3-Dichloropropene	ND	5.3	mg/kg
Ethylbenzene	6.0	3.2	mg/kg
Trichlorofluoromethane	ND	4.2	mg/kg
Hexachlorobutadiene	ND	5.3	mg/kg
Isopropylbenzene	3.5 F	8.5	mg/kg

(Continued on next page)

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POSB2-12

## GC/MS Volatiles

Lot-Sample #....: D8L110138-004 Work Order #....: CP7LW101 Matrix.....: SO

PARAMETER	RESULT	REPORTING LIMIT	UNITS
p-Isopropyltoluene	ND	6.3	mg/kg
Methylene chloride	ND	5.3	mg/kg
Naphthalene	22	5.3	mg/kg
n-Propylbenzene	4.4	2.1	mg/kg
Styrene	ND	2.1	mg/kg
1,1,1,2-Tetrachloroethane	ND	3.2	mg/kg
1,1,2,2-Tetrachloroethane	ND	2.1	mg/kg
Tetrachloroethene	ND	7.4	mg/kg
Toluene	ND	5.3	mg/kg
1,2,3-Trichlorobenzene	ND	2.1	mg/kg
1,2,4-Trichlorobenzene	ND	2.1	mg/kg
1,1,1-Trichloroethane	ND	4.2	mg/kg
1,1,2-Trichloroethane	ND	5.3	mg/kg
Trichloroethene	ND	11	mg/kg
1,2,3-Trichloropropane	ND	21	mg/kg
1,2,4-Trimethylbenzene	47	7.4	mg/kg
1,3,5-Trimethylbenzene	25	3.2	mg/kg
Vinyl chloride	ND	9.5	mg/kg
o-Xylene	5.6	5.3	mg/kg
m-Xylene & p-Xylene	42	3.2	mg/kg
1,2-Dibromo-3-chloropropane (DBCP)	ND	11	mg/kg
1,2-Dibromoethane (EDB)	ND	3.2	mg/kg
SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS	
1,2-Dichloroethane-d4	0.0 DIL,NC	(52 - 149)	
4-Bromofluorobenzene	0.0 DIL,NC	(65 - 135)	
Toluene-d8	0.0 DIL,NC	(65 - 135)	
Dibromofluoromethane	0.0 DIL,NC	(65 - 135)	

**NOTE(S) :**

DIL The concentration is estimated or not reported due to dilution or the presence of interfering analytes.

NC The recovery and/or RPD were not calculated.

Results and reporting limits have been adjusted for dry weight.

F The analyte was identified but the value was below the RL and above the MDL.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## GC/MS Semivolatiles

Lot-Sample #....: D8L110138-001    Work Order #....: CP7LP102    Matrix.....: WG  
 Date Sampled....: 12/10/98 09:20    Date Received...: 12/11/98  
 Prep Date.....: 12/17/98    Analysis Date...: 01/14/99  
 Prep Batch #....: 8349353    Analysis Time...: 05:24  
 Dilution Factor: 1  
 Method.....: CFR136A 625

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	10	ug/L
Acenaphthylene	ND	10	ug/L
Anthracene	1.1 J	10	ug/L
Benzidine	ND	100	ug/L
Benzo(a)anthracene	ND	10	ug/L
Benzo(b)fluoranthene	ND	10	ug/L
Benzo(ghi)perylene	ND	10	ug/L
Benzo(k)fluoranthene	ND	10	ug/L
Benzo(a)pyrene	ND	10	ug/L
4-Bromophenyl phenyl ether	ND	10	ug/L
Butyl benzyl phthalate	ND	10	ug/L
bis(2-Chloroethoxy) methane	ND	10	ug/L
bis(2-Chloroethyl) ether	ND	10	ug/L
bis(2-Chloroisopropyl) ether	ND	10	ug/L
4-Chloro-3-methylphenol	ND	10	ug/L
2-Chloronaphthalene	ND	10	ug/L
2-Chlorophenol	ND	10	ug/L
4-Chlorophenyl phenyl ether	ND	10	ug/L
Chrysene	ND	10	ug/L
Di-n-butyl phthalate	ND	10	ug/L
1,2-Dichlorobenzene	ND	10	ug/L
1,3-Dichlorobenzene	ND	10	ug/L
1,4-Dichlorobenzene	ND	10	ug/L
3,3'-Dichlorobenzidine	ND	50	ug/L
2,4-Dichlorophenol	ND	10	ug/L
Diethyl phthalate	ND	10	ug/L
2,4-Dimethylphenol	ND	10	ug/L
Dimethyl phthalate	ND	10	ug/L
2,4-Dinitrophenol	ND	50	ug/L
2,4-Dinitrotoluene	ND	10	ug/L
2,6-Dinitrotoluene	ND	10	ug/L
Di-n-octyl phthalate	ND	10	ug/L
1,2-Diphenylhydrazine	ND	10	ug/L
bis(2-Ethylhexyl) phthalate	ND	10	ug/L

(Continued on next page)

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## GC/MS Semivolatiles

Lot-Sample #....: D8L110138-001 Work Order #....: CP7LP102 Matrix.....: WG

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Fluoranthene	ND	10	ug/L
Fluorene	ND	10	ug/L
Hexachlorobenzene	ND	10	ug/L
Hexachlorobutadiene	ND	10	ug/L
Hexachlorocyclopentadiene	ND	50	ug/L
Hexachloroethane	ND	10	ug/L
Indeno (1,2,3-cd) pyrene	ND	10	ug/L
Isophorone	ND	10	ug/L
Naphthalene	110	10	ug/L
Nitrobenzene	ND	10	ug/L
2-Nitrophenol	ND	10	ug/L
4-Nitrophenol	ND	50	ug/L
N-Nitrosodimethylamine	ND	10	ug/L
N-Nitrosodi-n-propylamine	ND	10	ug/L
N-Nitrosodiphenylamine	ND	10	ug/L
Pentachlorophenol	ND	50	ug/L
Phenanthrene	7.6 J	10	ug/L
Phenol	ND	10	ug/L
Pyrene	ND	10	ug/L
1,2,4-Trichlorobenzene	ND	10	ug/L
2,4,6-Trichlorophenol	ND	10	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
2-Fluorophenol	86	(48 - 102)
Phenol-d5	91	(46 - 110)
Nitrobenzene-d5	71	(51 - 102)
2-Fluorobiphenyl	65	(39 - 91 )
2,4,6-Tribromophenol	103	(38 - 120)
Terphenyl-d14	42	(42 - 131)

**NOTE(S) :**

J Estimated result. Result is less than RL.

## PARSONS ENGINEERING SCIENCE, INC.

98POMP8-B

## GC/MS Semivolatiles

Lot-Sample #: D8L110138-001

Work Order #: CP7LP102

Matrix: WG

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Benzene, 1-ethyl-4-methyl-	622-96-8	210	M	ug/L
Benzene, 1,2,3-trimethyl-	526-73-8	110	M	ug/L
1,2,4-Trimethylbenzene	95-36-3	230	M	ug/L
Benzene, 1,3,5-trimethyl-	108-67-8	110	M	ug/L
Unknown #1	57-20-0	110	M	ug/L
Unknown #2	57-20-0	67	M	ug/L
Unknown #3	57-20-0	80	M	ug/L
Unknown #4	57-20-0	170	M	ug/L
Phenol, 2,6-dimethyl-	576-26-1	110	M	ug/L
(E)-1-phenyl-1-butene	1005-64-7	82	M	ug/L
1H-inden-1-one, 2,3-dihydro-	83-33-0	85	M	ug/L
Naphthalene, 2-methyl-	91-57-6	140	M	ug/L
Benzocycloheptatriene	264-09-5	100	M	ug/L
Benzeneacetic acid, .alpha.-#1	492-37-5	320	M	ug/L
Benzeneacetic acid, .alpha.-#2	492-37-5	120	M	ug/L
Unknown #5	57-20-0	26	M	ug/L
Naphthalene, 1,6-dimethyl-	575-43-9	37	M	ug/L
Unknown #6	57-20-0	120	M	ug/L
Unknown #7	57-20-0	67	M	ug/L
Unknown #8	57-20-0	25	M	ug/L
2-Naphthalenecarboxylic acid	93-09-4	140	M	ug/L

## NOTE (S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## GC Volatiles

Lot-Sample #....: D8L110138-001    Work Order #....: CP7LP103    Matrix.....: WG  
Date Sampled....: 12/10/98 09:20    Date Received...: 12/11/98  
Prep Date.....: 12/14/98    Analysis Date...: 12/14/98  
Prep Batch #....: 8349347    Analysis Time...: 13:51  
Dilution Factor: 10  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	4.2 J	5.0	ug/L
Chlorobenzene	5.8	5.0	ug/L
1,2-Dichlorobenzene	6.9	5.0	ug/L
1,3-Dichlorobenzene	8.0	5.0	ug/L
1,4-Dichlorobenzene	13	5.0	ug/L
Ethylbenzene	16	5.0	ug/L
Methyl tert-butyl ether	ND	50	ug/L
Toluene	8.7 B	5.0	ug/L
Xylenes (total)	61	5.0	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	89	(82 - 112)

## NOTE(S):

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

1C



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## GC Volatiles

Lot-Sample #....: D8L110138-001    Work Order #....: CP7LP108    Matrix.....: WG  
Date Sampled....: 12/10/98 09:20    Date Received...: 12/11/98  
Prep Date.....: 12/14/98    Analysis Date...: 12/14/98  
Prep Batch #....: 8349347    Analysis Time...: 13:51  
Dilution Factor: 10  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Benzene	3.9 J	5.0	ug/L
Chlorobenzene	7.2	5.0	ug/L
1,2-Dichlorobenzene	9.3	5.0	ug/L
1,3-Dichlorobenzene	9.4	5.0	ug/L
1,4-Dichlorobenzene	29	5.0	ug/L
Ethylbenzene	17	5.0	ug/L
Methyl tert-butyl ether	ND	50	ug/L
Toluene	8.9 B	5.0	ug/L
Xylenes (total)	68	5.0	ug/L

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
a,a,a-Trifluorotoluene (TFT)	94	(82 - 112)

## NOTE(S):

J Estimated result. Result is less than RL.

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

## GC Volatiles

Lot-Sample #....: D8L110138-003    Work Order #....: CP7LV101    Matrix.....: WG  
Date Sampled....: 12/09/98 14:40    Date Received...: 12/11/98  
Prep Date.....: 12/14/98    Analysis Date...: 12/14/98  
Prep Batch #....: 8349347    Analysis Time...: 15:39  
Dilution Factor: 10  
Method.....: CFR136A 602

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Benzene	30	5.0	ug/L
Chlorobenzene	ND	5.0	ug/L
1,2-Dichlorobenzene	ND	5.0	ug/L
1,3-Dichlorobenzene	ND	5.0	ug/L
1,4-Dichlorobenzene	ND	5.0	ug/L
Ethylbenzene	13	5.0	ug/L
Methyl tert-butyl ether	ND	50	ug/L
Toluene	ND	5.0	ug/L
Xylenes (total)	44	5.0	ug/L

SURROGATE	PERCENT	RECOVERY
	RECOVERY	LIMITS
a,a,a-Trifluorotoluene (TFT)	83	(82 - 112)

## NOTE(S):

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

## GC Volatiles

Lot-Sample #...: D8L110138-003    Work Order #...: CP7LV103    Matrix.....: WG  
Date Sampled...: 12/09/98 14:40    Date Received...: 12/11/98  
Prep Date.....: 12/14/98    Analysis Date...: 12/14/98  
Prep Batch #...: 8349347    Analysis Time...: 15:39  
Dilution Factor: 10  
Method.....: CFR136A 602

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u> <u>LIMIT</u>	<u>UNITS</u>
Benzene	32	5.0	ug/L
Chlorobenzene	ND	5.0	ug/L
1,2-Dichlorobenzene	ND	5.0	ug/L
1,3-Dichlorobenzene	ND	5.0	ug/L
1,4-Dichlorobenzene	ND	5.0	ug/L
Ethylbenzene	15	5.0	ug/L
Methyl tert-butyl ether	ND	50	ug/L
Toluene	ND	5.0	ug/L
Xylenes (total)	53	5.0	ug/L

<u>SURROGATE</u>	<u>PERCENT</u> <u>RECOVERY</u>	<u>RECOVERY</u> <u>LIMITS</u>
a,a,a-Trifluorotoluene (TFT)	92	(82 - 112)

NOTE(S):

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## HPLC

Lot-Sample #....: D8L110138-001    Work Order #....: CP7LP104PR    Matrix.....: WG  
 Date Sampled....: 12/10/98 09:20    Date Received...: 12/11/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/12/99  
 Prep Batch #....: 8350102    Analysis Time...: 17:12  
 Dilution Factor: 5  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Acenaphthene	ND	5.0	ug/L
Acenaphthylene	ND	5.0	ug/L
Anthracene	1.1	0.50	ug/L
Benzo(a)anthracene	ND	0.65	ug/L
Benzo(a)pyrene	ND	1.2	ug/L
Benzo(b)fluoranthene	ND	0.90	ug/L
Benzo(ghi)perylene	ND	1.0	ug/L
Benzo(k)fluoranthene	ND	0.85	ug/L
Chrysene	ND	1.0	ug/L
Dibenzo(a,h)anthracene	ND	1.5	ug/L
Fluoranthene	ND	1.0	ug/L
Fluorene	ND	1.0	ug/L
Indeno(1,2,3-cd)pyrene	ND	2.2	ug/L
Naphthalene	120	5.0	ug/L
Phenanthrene	9.7	1.0	ug/L
Pyrene	ND	1.0	ug/L

SURROGATE	PERCENT	RECOVERY
	RECOVERY	LIMITS
Terphenyl-d14	0.0 DIL, *	(25 - 157)

NOTE(S) :

DIL The concentration is estimated or not reported due to dilution or the presence of interfering analytes.

\* Surrogate recovery is outside stated control limits.

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

## HPLC

Lot-Sample #....: D8L110138-001    Work Order #....: CP7LP10H    Matrix.....: WG  
 Date Sampled....: 12/10/98 09:20    Date Received...: 12/11/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/12/99  
 Prep Batch #....: 8350102    Analysis Time...: 17:12  
 Dilution Factor: 5  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	5.0	ug/L
Acenaphthylene	ND	5.0	ug/L
Anthracene	1.0	0.50	ug/L
Benzo (a) anthracene	ND	0.65	ug/L
Benzo (a) pyrene	ND	1.2	ug/L
Benzo (b) fluoranthene	ND	0.90	ug/L
Benzo (ghi) perylene	ND	1.0	ug/L
Benzo (k) fluoranthene	ND	0.85	ug/L
Chrysene	ND	1.0	ug/L
Dibenzo (a,h) anthracene	ND	1.5	ug/L
Fluoranthene	ND	1.0	ug/L
Fluorene	ND	1.0	ug/L
Indeno (1,2,3-cd) pyrene	ND	2.2	ug/L
Naphthalene	120	5.0	ug/L
Phenanthrene	7.0	1.0	ug/L
Pyrene	ND	1.0	ug/L
	PERCENT	RECOVERY	
SURROGATE	RECOVERY	LIMITS	
Terphenyl-d14	0.0 DIL,*	(25 - 157)	

## NOTE (S) :

DIL The concentration is estimated or not reported due to dilution or the presence of interfering analytes.

\* Surrogate recovery is outside stated control limits.

2C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

## HPLC

Lot-Sample #....: D8L110138-003    Work Order #....: CP7LV102    Matrix.....: WG  
 Date Sampled....: 12/09/98 14:40    Date Received...: 12/11/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/06/99  
 Prep Batch #....: 8350102    Analysis Time...: 18:04  
 Dilution Factor: 1  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	1.0	ug/L
Acenaphthylene	ND	1.0	ug/L
Anthracene	0.43	0.10	ug/L
Benzo(a)anthracene	ND	0.13	ug/L
Benzo(a)pyrene	0.082 F	0.23	ug/L
Benzo(b)fluoranthene	0.21	0.18	ug/L
Benzo(ghi)perylene	ND	0.20	ug/L
Benzo(k)fluoranthene	ND	0.17	ug/L
Chrysene	ND	0.20	ug/L
Dibenzo(a,h)anthracene	ND	0.30	ug/L
Fluoranthene	2.1	0.20	ug/L
Fluorene	5.0	0.20	ug/L
Indeno(1,2,3-cd)pyrene	ND	0.43	ug/L
Naphthalene	20	1.0	ug/L
Phenanthrene	0.88	0.20	ug/L
Pyrene	ND	0.20	ug/L
SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS	
Terphenyl-d14	46	(25 - 157)	

## NOTE(S):

F The analyte was identified but the value was below the RL and above the MDL.

1C

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMW8-11

## HPLC

Lot-Sample #....: D8L110138-003    Work Order #....: CP7LV104    Matrix.....: WG  
 Date Sampled....: 12/09/98 14:40    Date Received...: 12/11/98  
 Prep Date.....: 12/16/98    Analysis Date...: 01/06/99  
 Prep Batch #....: 8350102    Analysis Time...: 18:04  
 Dilution Factor: 1  
 Method.....: SW846 8310

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Acenaphthene	ND	1.0	ug/L
Acenaphthylene	ND	1.0	ug/L
Anthracene	0.47	0.10	ug/L
Benzo (a) anthracene	ND	0.13	ug/L
Benzo (a) pyrene	0.088 F	0.23	ug/L
Benzo (b) fluoranthene	0.76	0.18	ug/L
Benzo (ghi) perylene	ND	0.20	ug/L
Benzo (k) fluoranthene	ND	0.17	ug/L
Chrysene	ND	0.20	ug/L
Dibenzo (a, h) anthracene	ND	0.30	ug/L
Fluoranthene	0.79	0.20	ug/L
Fluorene	2.1	0.20	ug/L
Indeno (1, 2, 3-cd) pyrene	ND	0.43	ug/L
Naphthalene	12	1.0	ug/L
Phenanthrene	2.3	0.20	ug/L
Pyrene	ND	0.20	ug/L
SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS	
Terphenyl-d14	46	(25 - 157)	

## NOTE(S) :

F The analyte was identified but the value was below the RL and above the MDL.

2C

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

General Chemistry

Lot-Sample #...: D8L110138-001 Work Order #...: CP7LP  
Date Sampled...: 12/10/98 09:20 Date Received...: 12/11/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	ND	1.0	mg/L	SW846 9056	12/11-12/12/98	8346203
Dilution Factor: 1				Analysis Time...: 00:30		



PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

General Chemistry

Lot-Sample #....: D8L110138-002    Work Order #....: CP7LQ  
Date Sampled....: 12/10/98 15:30    Date Received...: 12/11/98

Matrix.....: WG

<u>PARAMETER</u>	<u>RESULT</u>	<u>RL</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>PREP BATCH #</u>
Nitrate	ND	1.0	mg/L	SW846 9056	12/11-12/12/98	8346203

Dilution Factor: 1                      Analysis Time...: 01:16

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

GC Volatiles

Lot-Sample #....: D8L110138-001 Work Order #....: CP7LP205 Matrix.....: WG  
Date Sampled....: 12/10/98 09:20 Date Received...: 12/11/98  
Prep Date.....: 12/22/98 Analysis Date...: 12/22/98  
Prep Batch #....: 8357282 Analysis Time...: 16:45  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Methane	12	0.50	ug/L

NOTE(S) :

Diluted sample results do not match original analysis.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

GC Volatiles

Lot-Sample #....: D8L110138-002    Work Order #....: CP7LQ102    Matrix.....: WG  
Date Sampled....: 12/10/98 15:30    Date Received...: 12/11/98  
Prep Date.....: 12/22/98    Analysis Date...: 12/22/98  
Prep Batch #....: 8357282    Analysis Time...: 15:48  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u> <u>LIMIT</u>	<u>UNITS</u>
Methane	270 E	0.50	ug/L

NOTE(S) :

E Estimated result. Result concentration exceeds the calibration range.

PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-A

GC Volatiles

Lot-Sample #....: D8L110138-002    Work Order #....: CP7LQ202    Matrix.....: WG  
Date Sampled....: 12/10/98 15:30    Date Received...: 12/11/98  
Prep Date.....: 12/23/98    Analysis Date...: 12/23/98  
Prep Batch #....: 8357316    Analysis Time...: 13:16  
Dilution Factor: 50  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u> <u>LIMIT</u>	<u>UNITS</u>
Methane	3000 B,D	25	ug/L

NOTE(S) :

- B Method blank contamination. The associated method blank contains the target analyte at a reportable level.  
D Result was obtained from the analysis of a dilution.

Laboratory Non-Conformance  
Memo (NCM)



NCM Log Number

15797

4187

Project ID/Client

D8L040119#2,4,6 / D8L110138#4

Sample Numbers

NCM Initiated by/Date

MDJ 12/17/98

Project Manager

J. RIVIERE

Analyst/Team

M. Hoffman

Tests

8260

Analytical Area (check appropriate box)

- ☐ Sample control ☐ Organic preparation ☐ Inorganic preparation ☐ GC ☐ HPLC ☒ GC/MS ☐ Wet chemistry  
☐ Metals ☐ Reporting ☐ Data review ☐ Radiochemistry ☐

Non-Conformance (check appropriate box) To be completed by analyst

Holding Time Violation (exceeded by \_\_\_\_\_ days)

Category I: Laboratory Independent

- ☐ 1. Holding time expired in transit  
☐ 2. Sample received > 48 hours or 1/2 holding time has expired  
☐ 3. Test added by client after expiration

Category II: Laboratory Dependent

- ☐ 4. Instrument failure  
☐ 5. Analyst error  
☐ 6. Log-in error  
☐ 7. Miscommunication  
☐ 8. Other (explanation required)

Category III: Analysis Reruns (QA/QC)

- ☐ 9. Surrogates  
☐ 10. Internal standards  
☐ 11. Spike recoveries  
☐ 12. Blank contamination

Category IV: Analysis Reruns (Confirmation)

- ☐ 13. Second column  
☐ 14. Contamination check  
☐ 15. Confirmation of matrix effects  
☐ 16. Other (explanation required)

Quality Assurance/Quality Control

- ☒ 17. QC data reported outside of controls  
☐ 18. Incorrect procedure used  
☐ 19. SOP intentionally modified with QA and tech approval  
☐ 20. Invalid instrument calibration  
☐ 21. Received insufficient sample for proper analysis

Incorrect or Incomplete Client Deliverable

- ☐ 22. Hardcopy deliverable error  
☐ 23. Electronic deliverable error

Reported Detection Limits Elevated Due to:

- ☐ 24. Sample matrix: Does not include high analyte content  
☐ 25. Insufficient sample volume  
☐ 26. Other (explanation required)

Miscellaneous

- ☐ 27. Instrument Tag-out  
☐ 28. Other (explanation required)

Notification (check appropriate box) To be completed by project manager

Required ☐ Not Required

Client notified by - Name

Eileen LaRiviere

Date

12/21/98

☐ In writing

☐ By telephone

☐ By facsimile

☐ Other (explain)

Client's name and response

John Hicks

☒ Process "as is"

☐ On hold until

☐ Re-sample

☐ Other (explain)

Project manager signature

Eileen LaRiviere

Date

12/21/98

Laboratory Non-Conformance  
Memo (NCM)



NCM Log Number

15797

Corrective Action (To be completed and reviewed by all associates involved)

Problem Description/Root Cause

The LCS/LCSD has two compound outside acceptance limits. Bromomethane is recovered at 56% and 54% (limits 65-135), Dichlorodifluoromethane is recovered at 26% and 24% (limits 65-135). The cause of this is these gases are lost during a medium level soil prep. They are not as volatile in low-level prep.

Chaps is not controlled in MS/MSD (did fail there also)

Author's initials and date

mm 12/17/98

Corrective Actions (Short Term)

Report Data with footnotes

Author's initials and date

W 12/18/98

Corrective Actions to Prevent Recurrence (Long Term)

Look at Control Limit in Benzene to med level extracts

Corrective Action approved by Supervisor/Group Leader and date

cm R 12/18/98

Additional Comments

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

Quality Assurance Review (To be completed by a QA associate)

Log ID

☐

Anomaly

☒

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐

Further action required

☐

Further action assigned to

QA signature

Thom Lehman

Date

1/20/99

Corrective Action Verification (To be completed by a QA associate)

☐

Verification not required or requested

☐

Verified/CA completed on

by

Cannot verify (specify reason)

ed by

Date

Nonconformance Memo Closure

QA signature

Thom Lehman

Date

1/20/99

The office of Quality Assurance maintains a copy of this NCM indicating its final status.

**Laboratory Non-Conformance  
Memo (NCM)**



Project ID/Client JA-4187 B8L030177-01 - WMX D8L120137-01 D8L110138-01 } PARSONS	Sample Numbers	NCM Initiated by/Date F 1-15-99	NCM Log Number <div style="border: 1px solid black; padding: 5px; display: inline-block;">15694</div>
Analyst/Team K/BNA		Project Manager LARIVIERA DC ARZZO	

Tests  
625

**Analytical Area (check appropriate box)**

<input type="checkbox"/> Sample control	<input type="checkbox"/> Organic preparation	<input type="checkbox"/> Inorganic preparation	<input type="checkbox"/> GC	<input type="checkbox"/> HPLC	<input checked="" type="checkbox"/> GC/MS	<input type="checkbox"/> Wet chemistry
<input type="checkbox"/> Metals	<input type="checkbox"/> Reporting	<input type="checkbox"/> Data review	<input type="checkbox"/> Radiochemistry			

**Non-Conformance (check appropriate box) To be completed by analyst**

**Holding Time Violation (exceeded by \_\_\_\_\_ days)**

- Category I: Laboratory Independent**
- ☐ 1. Holding time expired in transit
  - ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
  - ☐ 3. Test added by client after expiration

- Category II: Laboratory Dependent**
- ☐ 4. Instrument failure
  - ☐ 5. Analyst error
  - ☐ 6. Log-in error
  - ☐ 7. Miscommunication
  - ☐ 8. Other (explanation required)

- Category III: Analysis Reruns (QA/QC)**
- ☐ 9. Surrogates
  - ☐ 10. Internal standards
  - ☐ 11. Spike recoveries
  - ☐ 12. Blank contamination

- Category IV: Analysis Reruns (Confirmation)**
- ☐ 13. Second column
  - ☐ 14. Contamination check
  - ☐ 15. Confirmation of matrix effects
  - ☐ 16. Other (explanation required)

**Quality Assurance/Quality Control**

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

**Incorrect or Incomplete Client Deliverable**

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

**Reported Detection Limits Elevated Due to:**

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required)

**Miscellaneous**

- ☐ 27. Instrument Tag-out
- ☒ 28. Other (explanation required)  
 EXPIRED LCS STANDARD (V11292)  
 USED BECAUSE LAB RAN OUT  
 OF STANDARD, AND THE SAMPLES  
 WOULD HAVE EXPIRED PRIOR TO  
 RECEIPT OF A REPLACEMENT STANDARD.

**Notification (check appropriate box) To be completed by project manager**

<input type="checkbox"/> Required <input type="checkbox"/> Not Required	
Verified by - Name _____	Date _____
<input type="checkbox"/> In writing <input type="checkbox"/> By telephone <input type="checkbox"/> By facsimile <input type="checkbox"/> Other (explain) _____	
Client's name and response _____	<input type="checkbox"/> Process "as is" <input type="checkbox"/> On hold until _____ <input type="checkbox"/> Re-sample <input type="checkbox"/> Other (explain) _____
Project manager signature _____	Date _____

**Laboratory Non-Conformance  
Memo (NCM)**

NCM Log Number

15694

Corrective Action (To be completed and reviewed by all associates involved)

Problem Description/Root Cause

SEE ATTACHMENT

Author's initials and date

K 1-15-99

Corrective Actions (Short Term)

THE SAMPLES HAVE EXPIRED. NOTIFY CLIENT PRIOR TO TAKING CORRECTIVE ACTION.

Author's initials and date

K 1-15-99

Corrective Actions to Prevent Recurrence (Long Term)

ENSURE THAT STANDARDS ARE REPLACED PRIOR TO ~~DISPATCH~~ DEPLETION.

Corrective Action approved by (Supervisor/Group Leader) and date

K 1-15-99

Additional Comments

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

Quality Assurance Review (To be completed by a QA associate)

Log ID

☐

Anomaly

☐

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐

Further action required

☐

Further action assigned to

QA signature

Date

Corrective Action Verification (To be completed by a QA associate)

☐

Verification not required or requested

☐

Verified/CA completed on \_\_\_\_\_ by \_\_\_\_\_

☐

Cannot verify (specify reason)

Date

by

Nonconformance Memo Closure

QA signature

Date



**Laboratory Non-Conformance  
Memo (NCM)**



4187	D8L100136-001, MS, SD	NCM Log Number	15897
Project ID/Client	D8L110138-001, 003	Sample Numbers	
Analyst/Team	8350102 D8L120137-001	NCM Initiated by/Date	D8L 11/18/99
		Project Manager	E. La Riviere

Tests **8310 PAH**

Analytical Area (check appropriate box)

<input type="checkbox"/> Sample control	<input type="checkbox"/> Organic preparation	<input type="checkbox"/> Inorganic preparation	<input type="checkbox"/> GC	<input checked="" type="checkbox"/> HPLC	<input type="checkbox"/> GC/MS	<input type="checkbox"/> Wet chemistry
<input type="checkbox"/> Metals	<input type="checkbox"/> Reporting	<input type="checkbox"/> Data review	<input type="checkbox"/> Radiochemistry	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Non-Conformance (check appropriate box) To be completed by analyst

Holding Time Violation (exceeded by \_\_\_\_\_ days)

Category I: Laboratory Independent

- ☐ 1. Holding time expired in transit
- ☐ 2. Sample received > 48 hours or 1/2 holding time has expired
- ☐ 3. Test added by client after expiration

Category II: Laboratory Dependent

- ☐ 4. Instrument failure
- ☐ 5. Analyst error
- ☐ 6. Log-in error
- ☐ 7. Miscommunication
- ☐ 8. Other (explanation required)

Category III: Analysis Reruns (QA/QC)

- ☐ 9. Surrogates
- ☐ 10. Internal standards
- ☐ 11. Spike recoveries
- ☐ 12. Blank contamination

Category IV: Analysis Reruns (Confirmation)

- ☐ 13. Second column
- ☐ 14. Contamination check
- ☐ 15. Confirmation of matrix effects
- ☐ 16. Other (explanation required) \_\_\_\_\_

Quality Assurance/Quality Control

- ☒ 17. QC data reported outside of controls
- ☐ 18. Incorrect procedure used
- ☐ 19. SOP intentionally modified with QA and tech approval
- ☐ 20. Invalid instrument calibration
- ☐ 21. Received insufficient sample for proper analysis

Incorrect or Incomplete Client Deliverable

- ☐ 22. Hardcopy deliverable error
- ☐ 23. Electronic deliverable error

Reported Detection Limits Elevated Due to:

- ☐ 24. Sample matrix: Does not include high analyte content
- ☐ 25. Insufficient sample volume
- ☐ 26. Other (explanation required)

Miscellaneous

- ☐ 27. Instrument Tag-out
- ☐ 28. Other (explanation required) \_\_\_\_\_

Notification (check appropriate box) To be completed by project manager

Required ☒ Not Required

Client notified by - Name	Date	<input type="checkbox"/> In writing	<input type="checkbox"/> By telephone	<input type="checkbox"/> By facsimile	<input type="checkbox"/> Other (explain) _____
---------------------------	------	-------------------------------------	---------------------------------------	---------------------------------------	------------------------------------------------

Client's name and response	<input type="checkbox"/> Process "as is"	<input type="checkbox"/> On hold until _____	<input type="checkbox"/> Re-sample	<input type="checkbox"/> Other (explain) _____
----------------------------	------------------------------------------	----------------------------------------------	------------------------------------	------------------------------------------------

Project manager signature	Date
<i>E. La Riviere</i>	11/19/99

- 83 -

Lot #: DBL110138 Date/Time Received: 12/11/98 0900Company Name & Sampling Site: ARC013

\*Cooler #(s): \_\_\_\_\_

Temperatures: 3.4 \_\_\_\_\_

## Unpacking &amp; Labeling Check Points:

Y/N

- | Yes                                 | No                                  |                                                       | (_____ mR/hr) |          |
|-------------------------------------|-------------------------------------|-------------------------------------------------------|---------------|----------|
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 1. Radiation checked, record if reading > 0.5 mR/hr.  |               | <u>✓</u> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 2. Cooler seals intact.                               |               |          |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 3. Chain of custody present.                          |               |          |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 4. Bottles broken and/or are leaking, comment if yes. |               |          |

PHOTOGRAPH BROKEN BOTTLES

- |                                     |                                     |                                                                                                |           |
|-------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------|-----------|
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 5. Containers labeled, comment if no.                                                          |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 6. pH of all samples checked and meet requirements, note exceptions.                           |           |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 7. Chain of custody includes "received by" and "relinquished" by signatures, dates, and times. | <u>NO</u> |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 8. Receipt date(s) > 48 hours past the collection date(s)? If yes, notify PA/PM.               |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 9. Chain of custody agrees with bottle count, comment if no.                                   |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 10. Chain of custody agrees with labels, comment if no.                                        |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 11. VOA samples filled completely, comment if no.                                              |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 12. VOA bottles preserved, check for labels.                                                   |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 13. Did samples require preservation with sodium thiosulfate?                                  |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 14. If yes to #12, did the samples contain residual chlorine?                                  |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 15. Sediment present in "D," dissolved, bottles.                                               |           |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 16. Are analyses with short holding times requested?                                           |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 17. Is extra sample volume provided for MS, MSD or matrix duplicates?                          |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 18. Multiphase samples present? If yes, comment below.                                         |           |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 19. Any subsampling for volatiles? If yes, list samples.                                       |           |

PHOTOGRAPH MULTIPHASE SAMPLES

- |                          |                          |                                                                  |  |
|--------------------------|--------------------------|------------------------------------------------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | 20. Clear picture taken, labeled, and stapled to project folder. |  |
| <input type="checkbox"/> | <input type="checkbox"/> | 21. Subcontract CCC signed and sent with samples to bottle prep? |  |
| <input type="checkbox"/> | <input type="checkbox"/> | 22. Was sample labeling double checked?                          |  |

Comments: Include action taken to resolve discrepancies/problems. Include a hard copy of e-mail or use extra paper if more space is needed.

Initials: \_\_\_\_\_

Revision 4 6/25/98

C:\VOLATILE\SAMPLES\12110138\12110138.PRC

**Laboratory Non-Conformance  
Memo (NCM)**



NCM Log Number

15693

4187

Project ID/Client D8L110138-04

Sample Numbers

NCM Initiated by/Date

Project Manager

D8L120139-05-06

W 1-19-99

LARIVIERE

Analyst/Team

Testis

8270

**Analytical Area (check appropriate box)**

- ☐ Sample control ☒ Organic preparation ☐ Inorganic preparation ☐ GC ☐ HPLC ☐ GC/MS ☐ Wet chemistry  
☐ Metals ☐ Reporting ☐ Data review ☐ Radiochemistry

**Non-Conformance (check appropriate box) To be completed by analyst**

Holding Time Violation (exceeded by > 26 days)

**Category I: Laboratory Independent**

- ☐ 1. Holding time expired in transit  
☐ 2. Sample received > 48 hours or 1/2 holding time has expired  
☐ 3. Test added by client after expiration

**Category II: Laboratory Dependent**

- ☒ 4. Instrument failure  
☒ 5. Analyst error  
☐ 6. Log-in error  
☐ 7. Miscommunication  
☐ 8. Other (explanation required)

**Category III: Analysis Reruns (QA/QC)**

- ☐ 9. Surrogates  
☐ 10. Internal standards  
☐ 11. Spike recoveries  
☐ 12. Blank contamination

**Category IV: Analysis Reruns (Confirmation)**

- ☐ 13. Second column  
☐ 14. Contamination check  
☐ 15. Confirmation of matrix effects  
☐ 16. Other (explanation required)

**Quality Assurance/Quality Control**

- ☐ 17. QC data reported outside of controls  
☐ 18. Incorrect procedure used  
☐ 19. SOP intentionally modified with QA and tech approval  
☐ 20. Invalid instrument calibration  
☐ 21. Received insufficient sample for proper analysis

**Incorrect or Incomplete Client Deliverable**

- ☐ 22. Hardcopy deliverable error  
☐ 23. Electronic deliverable error

**Reported Detection Limits Elevated Due to:**

- ☐ 24. Sample matrix: Does not include high analyte content  
☐ 25. Insufficient sample volume  
☐ 26. Other (explanation required)

**Miscellaneous**

- ☐ 27. Instrument Tag-out  
☒ 28. Other (explanation required)

THE SAMPLES WERE NOT  
EXTRACTED

**Notification (check appropriate box) To be completed by project manager**

☒ Required ☐ Not Required

Client notified by - Name

Date

- ☐ In writing ☐ By telephone ☐ By facsimile ☐ Other (explain)

Client's name and response

- ☐ Process "as is" ☐ On hold until ☐ Re-sample ☐ Other (explain)

Project manager signature

Date

105

**Laboratory Non-Conformance  
Memo (NCM)**



NCM Log Number

15693

Corrective Action (To be completed and reviewed by all associates involved)

Problem Description/Root Cause

DUE TO AN ANALYST ERROR THE SAMPLES WERE NOT EXTRACTED. THE SAMPLES  
WERE BATCHED (THIS TAKES THEM OFF THE BACKLOG REPORT) BUT THERE IS  
NO INDICATION THE SAMPLES WERE EVER EXTRACTED

Author's initials and date

KE 1-19-99

Corrective Actions (Short Term)

NOTIFY CLIENT AND SEE WHAT THEY WANT DONE.

Author's initials and date

KE 1-19-99

Corrective Actions to Prevent Reoccurrence (Long Term)

Corrective Action approved by (Supervisor/Group Leader) and date

Additional Comments

Corrective Action to be completed by (if other than Supervisor/Group Leader)

Date Corrective Action is to be completed

Quality Assurance Review (To be completed by a QA associate)

Log ID

☐

Anomaly

☐

Deficiency

☐

Notified Ops/Sys Manager (Initials)

☐

Further action required

☐

Further action assigned to

QA signature

Date

Corrective Action Verification (To be completed by a QA associate)

☐

Verification not required or requested

☐

Verified/CA completed on

by

☐

Cannot verify (specify reason)

ed by

Date

Nonconformance Memo Closure

QA signature

Date

The office of Quality Assurance maintains a copy of this NCM indicating its final status.



Client: **Parsons Engineering Science, Inc.**  
Address: **1700 Broadway Suite 900**  
City: **Denver** State: **CO** Zip Code: **80240**  
Project Name: **AFCEE RBCH Investigation**  
Contract/Purchase Order/Quote No.:

Project Manager: **John Hicks**  
Telephone Number (Area Code)/Fax Number: **303-831-8100**  
Site Contact: **T. Drago** Lab Contact: **Ellen Levine**  
Carrier/Waybill Number:

Date: **12/11/98** Chain of Custody Number: **19503**  
Lab Number:  Page: **1** of **1**

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix					Containers & Preservatives					Analysis (Attach list if more space is needed)	Special Instructions/ Conditions of Receipt
			Aqueous	Sol	Sed	Unpres	H2SO4	HNO3	HCl	NaOH	ZnAc	NaOH		
98POM8-A	12-10-98	15:30	X						X				METHANE RSK-175	
<del>98POM8-B</del>	<del>12-10-98</del>	<del>11:30</del>	<del>X</del>						X				METHANE RSK-175	
<del>98POM8-C</del>	<del>12-10-98</del>	<del>11:40</del>	<del>X</del>						X				METHANE RSK-175	
<del>98POM8-D</del>	<del>12-10-98</del>	<del>11:40</del>	<del>X</del>						X				METHANE RSK-175	
98POM8-B	12-10-98	9:20	X						X					91045 (3 sets of 3)

Possible Hazard Identification  
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Turn Around Time Required  
☐ 24 Hours ☒ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other

1. Relinquished By: *[Signature]* Date: **12/11/98** Time: **1900**  
2. Relinquished By: *[Signature]* Date:  Time:

3. Relinquished By: *[Signature]* Date:  Time:

Comments:

(A fee may be assessed if samples are retained longer than 3 months)

Disposal By Lab ☐ Archive For ☐ Months ☐ Months

QC Requirements (Specify)

Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

## ANALYTICAL REPORT

Pope AFB  
Lot #: D9B030153

John Hicks  
Parsons Engineering Services

QUANTERRA INCORPORATED

  
Ellen La Riviere  
Project Manager

February 12, 1999



PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: 98POMP8-B

GC Volatiles

Lot-Sample #....: D8L110138-001 Work Order #....: CP7LP105 Matrix.....: WG  
Date Sampled....: 12/10/98 09:20 Date Received...: 12/11/98  
Prep Date.....: 12/22/98 Analysis Date...: 12/22/98  
Prep Batch #....: 8357282 Analysis Time...: 15:13  
Dilution Factor: 1  
Method.....: EPA-9 RSK-175

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u> <u>LIMIT</u>	<u>UNITS</u>
Methane	140 B,E	0.50	ug/L

NOTE(S) :

B Method blank contamination. The associated method blank contains the target analyte at a reportable level.  
E Estimated result. Result concentration exceeds the calibration range.

# Table Of Contents

## Standard Deliverables With Supporting Documentation

Section	Report Contents	Number of Pages
---------	-----------------	-----------------

### Standard Deliverables

#### A. Introduction

59

- Table of Contents
- Case Narrative
- Executive Summary – Detection
- Analytical Methods Summary
- Method/Analyst Summary
- Lot Sample Summary
- Analytical Results by Sample
- QC Data Association Summary
- Chain-of-Custody

### Supporting Documentation

*[Please Note: A one-page "Description of Supporting Documentation" is provided in the Supporting Documentation section(s).]*

#### B. • Volatile GC/MS

#### C. • Semivolatile GC/MS

#### D. • Volatile GC

#### E. • Semivolatile GC

#### F. • LC/MS or HPLC

#### G. • Metals

#### H. • General Chemistry

#### I. • Subcontracted Data

Total # Pages in this Package

## **Project Narrative**

**(D9B030153)**

With the exceptions noted on the data sheets, standard analytical protocols were followed in the analyses of the samples and no problems were encountered or anomalies observed. All laboratory quality control samples analyzed in conjunction with the samples in this project were within established control limits.

### **GC/MS Volatiles**

In the LCS/LCSD associated with sample D9B030153-002, 1,1,1,2-tetrachloroethane was recovered above the upper control limits. Because this would indicate a high bias to the data and this compound was not detected in the sample, no further action was required.

The relative percent difference exceeded the control limit for chloroethane in the LCS/LCSD associated with sample D9B030153-002. The individual percent recoveries were within the control limits for this compound. Chloroethane was not detected in the sample.

### **GC/MS Semi-Volatiles**

Elevated concentrations of non-target compounds were detected in all of the samples. The MS/MSD had recoveries outside of QC acceptance criteria. However, since the associated method blank and LCS were in control, no corrective action was taken. The analyst reported that the MS extract was darker in color than the corresponding MSD and sample extract. A greater concentration of non-target compounds was also detected in the MS sample than in the corresponding samples.

# EXECUTIVE SUMMARY - Detection Highlights

D9B030153

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
POSB-2R-12 02/02/99 12:00 001				
bis(2-Ethylhexyl) phthalate	0.50 F	0.81	mg/kg	SW846 8270B
Fluoranthene	0.29 F	0.81	mg/kg	SW846 8270B
Fluorene	0.23 F	0.81	mg/kg	SW846 8270B
2-Methylnaphthalene	1.2	0.81	mg/kg	SW846 8270B
Phenanthrene	0.63 F	0.81	mg/kg	SW846 8270B
Pyrene	0.28 F	0.81	mg/kg	SW846 8270B
Percent Moisture	13.3	0.10	%	MCAWW 160.3 MOD
POSB-3R-12 02/02/99 13:10 002				
Benzene	0.0048 F	0.0062	mg/kg	SW846 8260A
n-Butylbenzene	0.0035 F	0.015	mg/kg	SW846 8260A
sec-Butylbenzene	0.0024 F	0.022	mg/kg	SW846 8260A
Ethylbenzene	0.045	0.0092	mg/kg	SW846 8260A
Isopropylbenzene	0.0090 F	0.025	mg/kg	SW846 8260A
p-Isopropyltoluene	0.0043 F	0.018	mg/kg	SW846 8260A
Methylene chloride	0.0023 F	0.015	mg/kg	SW846 8260A
Naphthalene	0.040	0.015	mg/kg	SW846 8260A
n-Propylbenzene	0.0086	0.0062	mg/kg	SW846 8260A
1,2,4-Trimethylbenzene	0.073	0.022	mg/kg	SW846 8260A
1,3,5-Trimethylbenzene	0.073	0.0092	mg/kg	SW846 8260A
o-Xylene	0.032	0.015	mg/kg	SW846 8260A
m-Xylene & p-Xylene	0.091	0.0037	mg/kg	SW846 8260A
Percent Moisture	18.8	0.10	%	MCAWW 160.3 MOD
POSB-4R-12 02/02/99 12:50 003				
Acenaphthene	0.56 F	0.83	mg/kg	SW846 8270B
Anthracene	0.57 F	0.83	mg/kg	SW846 8270B
Benzo(a)anthracene	0.45 F	0.83	mg/kg	SW846 8270B
Benzo(b)fluoranthene	0.21 F	0.83	mg/kg	SW846 8270B
Benzo(a)pyrene	0.24 F	0.83	mg/kg	SW846 8270B
Chrysene	0.43 F	0.83	mg/kg	SW846 8270B
Dibenzofuran	0.35 F	0.83	mg/kg	SW846 8270B
Fluoranthene	1.3	0.83	mg/kg	SW846 8270B
Fluorene	0.93	0.83	mg/kg	SW846 8270B
2-Methylnaphthalene	4.0	0.83	mg/kg	SW846 8270B
Naphthalene	0.55 F	0.83	mg/kg	SW846 8270B
Phenanthrene	2.7	0.83	mg/kg	SW846 8270B
Pyrene	1.3	0.83	mg/kg	SW846 8270B
Percent Moisture	16.0	0.10	%	MCAWW 160.3 MOD

# ANALYTICAL METHODS SUMMARY

D9B030153

<u>PARAMETER</u>	<u>ANALYTICAL METHOD</u>
Percent Moisture	MCAWW 160.3 MOD
Semivolatile Organic Compounds by GC/MS	SW846 8270B
Volatile Organics by GC/MS	SW846 8260A

## References:

- MCAWW "Methods for Chemical Analysis of Water and Wastes",  
EPA-600/4-79-020, March 1983 and subsequent revisions.
- SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical  
Methods", Third Edition, November 1986 and its updates.

## METHOD / ANALYST SUMMARY

D9B030153

<u>ANALYTICAL METHOD</u>	<u>ANALYST</u>	<u>ANALYST ID</u>
MCAWW 160.3 MOD	Andrea Sporleder	001971
SW846 8260A	Kerri Keller	000517
SW846 8270B	Deborah Coyle	001425

### References:

MCAWW "Methods for Chemical Analysis of Water and Wastes",  
EPA-600/4-79-020, March 1983 and subsequent revisions.

SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical  
Methods", Third Edition, November 1986 and its updates.

## SAMPLE SUMMARY

D9B030153

<u>WO #</u>	<u>SAMPLE#</u>	<u>CLIENT SAMPLE ID</u>	<u>DATE</u>	<u>TIME</u>
CQG15	001	POSB-2R-12	02/02/99	12:00
CQG16	002	POSB-3R-12	02/02/99	13:10
CQG17	003	POSB-4R-12	02/02/99	12:50

### NOTE (S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-3R-12

## GC/MS Volatiles

Lot-Sample #....: D9B030153-002    Work Order #....: CQG16101    Matrix.....: SO  
 Date Sampled....: 02/02/99 13:10    Date Received...: 02/03/99  
 Prep Date.....: 02/08/99    Analysis Date...: 02/08/99  
 Prep Batch #....: 9040324    Analysis Time...: 15:03  
 Dilution Factor: 2.5  
 % Moisture.....: 19    Method.....: SW846 8260A

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Benzene	0.0048 F	0.0062	mg/kg
Bromobenzene	ND	0.0062	mg/kg
Bromochloromethane	ND	0.0062	mg/kg
Bromodichloromethane	ND	0.012	mg/kg
Bromoform	ND	0.018	mg/kg
Bromomethane	ND	0.015	mg/kg
n-Butylbenzene	0.0035 F	0.015	mg/kg
sec-Butylbenzene	0.0024 F	0.022	mg/kg
tert-Butylbenzene	ND	0.022	mg/kg
Carbon tetrachloride	ND	0.031	mg/kg
Chlorobenzene	ND	0.0062	mg/kg
Chlorodibromomethane	ND	0.012	mg/kg
Chloroethane	ND	0.015	mg/kg
Chloroform	ND	0.0062	mg/kg
1-Chlorohexane	ND	0.0092	mg/kg
Chloromethane	ND	0.022	mg/kg
2-Chlorotoluene	ND	0.0062	mg/kg
4-Chlorotoluene	ND	0.0092	mg/kg
Dibromomethane	ND	0.031	mg/kg
1,2-Dichlorobenzene	ND	0.0062	mg/kg
1,3-Dichlorobenzene	ND	0.018	mg/kg
1,4-Dichlorobenzene	ND	0.0062	mg/kg
Dichlorodifluoromethane	ND	0.015	mg/kg
1,1-Dichloroethane	ND	0.0062	mg/kg
1,2-Dichloroethane	ND	0.0092	mg/kg
1,1-Dichloroethene	ND	0.018	mg/kg
cis-1,2-Dichloroethene	ND	0.018	mg/kg
trans-1,2-Dichloroethene	ND	0.0092	mg/kg
1,2-Dichloropropane	ND	0.0062	mg/kg
1,3-Dichloropropane	ND	0.0062	mg/kg
2,2-Dichloropropane	ND	0.062	mg/kg
1,1-Dichloropropene	ND	0.015	mg/kg
cis-1,3-Dichloropropene	ND	0.015	mg/kg
trans-1,3-Dichloropropene	ND	0.015	mg/kg
Ethylbenzene	0.045	0.0092	mg/kg
Trichlorofluoromethane	ND	0.012	mg/kg
Hexachlorobutadiene	ND	0.015	mg/kg
Isopropylbenzene	0.0090 F	0.025	mg/kg

(Continued on next page)



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-3R-12

## GC/MS Volatiles

Lot-Sample #....: D9B030153-002 Work Order #....: CQG16101 Matrix.....: SO

PARAMETER	RESULT	REPORTING LIMIT	UNITS
p-Isopropyltoluene	0.0043 F	0.018	mg/kg
Methylene chloride	0.0023 F	0.015	mg/kg
Naphthalene	0.040	0.015	mg/kg
n-Propylbenzene	0.0086	0.0062	mg/kg
Styrene	ND	0.0062	mg/kg
1,1,1,2-Tetrachloroethane	ND	0.0092	mg/kg
1,1,2,2-Tetrachloroethane	ND	0.0062	mg/kg
Tetrachloroethene	ND	0.022	mg/kg
Toluene	ND	0.015	mg/kg
1,2,3-Trichlorobenzene	ND	0.0062	mg/kg
1,2,4-Trichlorobenzene	ND	0.0062	mg/kg
1,1,1-Trichloroethane	ND	0.012	mg/kg
1,1,2-Trichloroethane	ND	0.015	mg/kg
Trichloroethene	ND	0.031	mg/kg
1,2,3-Trichloropropane	ND	0.062	mg/kg
1,2,4-Trimethylbenzene	0.073	0.022	mg/kg
1,3,5-Trimethylbenzene	0.073	0.0092	mg/kg
Vinyl chloride	ND	0.028	mg/kg
o-Xylene	0.032	0.015	mg/kg
m-Xylene & p-Xylene	0.091	0.0037	mg/kg
1,2-Dibromo-3-chloropropane (DBCP)	ND	0.031	mg/kg
1,2-Dibromoethane (EDB)	ND	0.0092	mg/kg

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
Dibromofluoromethane	103	(65 - 135)
Toluene-d8	102	(65 - 135)
4-Bromofluorobenzene	107	(65 - 135)
1,2-Dichloroethane-d4	101	(52 - 149)

**NOTE(S) :**

F The analyte was identified but the value was below the RL and above the MDL.

Results and reporting limits have been adjusted for dry weight.

Elevated reporting limits. The reporting limits are elevated due to matrix interference.

T1 - Tentative identification - some or all of major ions present; ratios may be variable.

T2 - Confident identification - major ions and ratios largely agree.

## PARSONS ENGINEERING SCIENCE, INC.

POSB-3R-12

## GC/MS Volatiles

Lot-Sample #: D9B030153-002

Work Order #: CQG16101

Matrix: SO

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Butane, 2-methyl-	78-78-4	0.019 T2 M	3.208	mg/kg
Cyclopentane, methyl-	96-37-7	0.032 T2 M	6.035	mg/kg
Cyclohexane	110-82-7	0.048 T2 M	6.887	mg/kg
Pentane, 2,2,4-trimethyl-	540-84-1	0.064 T2 M	7.358	mg/kg
Pentane, 2,3,4-trimethyl-	565-75-3	0.041 T2 M	7.358	mg/kg
Pentane, 2,3,3-trimethyl-	560-21-4	0.062 T1 M	8.917	mg/kg
Benzene, 1-ethyl-4-methyl-	622-96-8	0.046 T2 M	12.903	mg/kg
Benzene, 1,3,5-trimethyl-	108-67-8	0.042 T2 M	12.994	mg/kg

NOTE(S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-2R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-001    Work Order #....: CQG15101    Matrix.....: SO  
 Date Sampled....: 02/02/99 12:00    Date Received...: 02/03/99  
 Prep Date.....: 02/03/99    Analysis Date...: 02/08/99  
 Prep Batch #....: 9034303    Analysis Time...: 13:49  
 Dilution Factor: 1  
 % Moisture.....: 13    Method.....: SW846 8270B

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Acenaphthene	ND	0.81	mg/kg
Acenaphthylene	ND	0.81	mg/kg
Anthracene	ND	0.81	mg/kg
Benzo(a)anthracene	ND	0.81	mg/kg
Benzo(b)fluoranthene	ND	0.81	mg/kg
Benzoic acid	ND	1.8	mg/kg
Benzo(ghi)perylene	ND	0.81	mg/kg
Benzo(a)pyrene	ND	0.81	mg/kg
bis(2-Chloroethoxy) methane	ND	0.81	mg/kg
bis(2-Chloroethyl) ether	ND	0.81	mg/kg
bis(2-Ethylhexyl) phthalate	0.50 F	0.81	mg/kg
4-Bromophenyl phenyl ether	ND	0.81	mg/kg
Butyl benzyl phthalate	ND	0.81	mg/kg
4-Chloroaniline	ND	1.5	mg/kg
4-Chloro-3-methylphenol	ND	1.5	mg/kg
2-Chlorophenol	ND	0.81	mg/kg
4-Chlorophenyl phenyl ether	ND	0.81	mg/kg
Chrysene	ND	0.81	mg/kg
Dibenz(a,h)anthracene	ND	0.81	mg/kg
Dibenzofuran	ND	0.81	mg/kg
1,2-Dichlorobenzene	ND	0.81	mg/kg
1,3-Dichlorobenzene	ND	0.81	mg/kg
1,4-Dichlorobenzene	ND	0.81	mg/kg
3,3'-Dichlorobenzidine	ND	1.5	mg/kg
2,4-Dichlorophenol	ND	0.35	mg/kg
Diethyl phthalate	ND	0.81	mg/kg
2,4-Dimethylphenol	ND	0.35	mg/kg
Dimethyl phthalate	ND	0.81	mg/kg
4,6-Dinitro- 2-methylphenol	ND	3.8	mg/kg
2,4-Dinitrophenol	ND	3.8	mg/kg
2,4-Dinitrotoluene	ND	0.81	mg/kg
2,6-Dinitrotoluene	ND	0.81	mg/kg
Di-n-octyl phthalate	ND	0.81	mg/kg

(Continued on next page)

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-2R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-001 Work Order #....: CQG15101 Matrix.....: SO

PARAMETER	RESULT	REPORTING LIMIT	UNITS
Fluoranthene	0.29 F	0.81	mg/kg
Fluorene	0.23 F	0.81	mg/kg
Hexachlorobenzene	ND	0.81	mg/kg
Hexachlorobutadiene	ND	0.81	mg/kg
Hexachlorocyclopentadiene	ND	0.81	mg/kg
Hexachloroethane	ND	0.81	mg/kg
Indeno(1,2,3-cd)pyrene	ND	0.81	mg/kg
Isophorone	ND	0.81	mg/kg
2-Methylnaphthalene	1.2	0.81	mg/kg
2-Methylphenol	ND	0.35	mg/kg
Naphthalene	ND	0.81	mg/kg
2-Nitroaniline	ND	3.8	mg/kg
3-Nitroaniline	ND	3.8	mg/kg
4-Nitroaniline	ND	3.8	mg/kg
Nitrobenzene	ND	0.81	mg/kg
2-Nitrophenol	ND	0.35	mg/kg
4-Nitrophenol	ND	1.8	mg/kg
N-Nitrosodiphenylamine	ND	0.81	mg/kg
N-Nitrosodi-n-propylamine	ND	0.81	mg/kg
Pentachlorophenol	ND	3.8	mg/kg
Phenanthrene	0.63 F	0.81	mg/kg
Phenol	ND	0.35	mg/kg
Pyrene	0.28 F	0.81	mg/kg
1,2,4-Trichlorobenzene	ND	0.81	mg/kg
2,4,5-Trichlorophenol	ND	3.8	mg/kg
Benzyl alcohol	ND	1.5	mg/kg
bis(2-Chloroisopropyl) ether	ND	0.81	mg/kg
2-Chloronaphthalene	ND	0.81	mg/kg
Di-n-butyl phthalate	ND	0.81	mg/kg
4-Methylphenol	ND	0.35	mg/kg
2,4,6-Trichlorophenol	ND	0.35	mg/kg

SURROGATE	PERCENT RECOVERY	RECOVERY LIMITS
2,4,6-Tribromophenol	77	(25 - 144)
2-Fluorobiphenyl	71	(34 - 135)
2-Fluorophenol	73	(25 - 135)
Nitrobenzene-d5	68	(25 - 135)
Phenol-d5	72	(25 - 135)
Terphenyl-d14	78	(32 - 136)

## NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

F The analyte was identified but the value was below the RL and above the MDL.

## PARSONS ENGINEERING SCIENCE, INC.

POSB-2R-12

## GC/MS Semivolatiles

Lot-Sample #: D9B030153-001

Work Order #: CQG15101

Matrix: SO

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Aldol condensation product		13 B	M	mg/kg
Unknown #1	57-20-0	0.63	M	mg/kg
Tridecane #1	629-50-5	1.3	M	mg/kg
Naphthalene, 1-methyl-	90-12-0	0.89	M	mg/kg
Unknown #2	57-20-0	0.63	M	mg/kg
Tridecane, 2-methyl-	1560-96-9	0.61	M	mg/kg
Dodecane, 2,6,11-trimethyl-	31295-56-4	0.97	M	mg/kg
Tetradecane	629-59-4	1.9	M	mg/kg
Naphthalene, 2,6-dimethyl- #1	581-42-0	1.1	M	mg/kg
Naphthalene, 2,6-dimethyl- #2	581-42-0	1.2	M	mg/kg
Naphthalene, 2,6-dimethyl- #3	581-42-0	1.3	M	mg/kg
Cyclotetradecane	295-17-0	0.64	M	mg/kg
Dodecane, 2-methyl-8-propyl-	55045-07-3	1.3	M	mg/kg
Naphthalene, 1,5-dimethyl-	571-61-9	0.59	M	mg/kg
Naphthalene, 1,7-dimethyl-	575-37-1	0.61	M	mg/kg
Pentadecane	629-62-9	2.1	M	mg/kg
Naphthalene, 1,4,6-trimethyl#1	2131-42-2	0.74	M	mg/kg
Naphthalene, 1,4,6-trimethyl#2	2131-42-2	1.0	M	mg/kg
Naphthalene, 2,3,6-trimethyl-	829-26-5	0.86	M	mg/kg
Naphthalene, 1,4,6-trimethyl#3	2131-42-2	0.57	M	mg/kg
Naphthalene, 1,6,7-trimethyl-	2245-38-7	0.59	M	mg/kg
Hexadecane	544-76-3	2.2	M	mg/kg
Tridecane #2	629-50-5	1.5	M	mg/kg
Unknown #3	57-20-0	0.53	M	mg/kg
Heptadecane	629-78-7	3.0	M	mg/kg
Pentadecane, 2,6,10,14-tetrame	1921-70-6	2.8	M	mg/kg
Unknown #4	57-20-0	1.2	M	mg/kg
Tridecane #3	629-50-5	2.6	M	mg/kg
Dodecane, 2,6,10-trimethyl-	3891-98-3	1.5	M	mg/kg
Nonadecane	629-92-5	1.4	M	mg/kg

NOTE(S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.

## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-3R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-002    Work Order #....: CQG16102    Matrix.....: SO  
 Date Sampled....: 02/02/99 13:10    Date Received...: 02/03/99  
 Prep Date.....: 02/03/99    Analysis Date...: 02/08/99  
 Prep Batch #....: 9034303    Analysis Time...: 15:31  
 Dilution Factor: 1  
 % Moisture.....: 19    Method.....: SW846 8270B

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Acenaphthene	ND	0.86	mg/kg
Acenaphthylene	ND	0.86	mg/kg
Anthracene	ND	0.86	mg/kg
Benzo(a)anthracene	ND	0.86	mg/kg
Benzo(b)fluoranthene	ND	0.86	mg/kg
Benzoic acid	ND	2.0	mg/kg
Benzo(ghi)perylene	ND	0.86	mg/kg
Benzo(a)pyrene	ND	0.86	mg/kg
bis(2-Chloroethoxy) methane	ND	0.86	mg/kg
bis(2-Chloroethyl) ether	ND	0.86	mg/kg
bis(2-Ethylhexyl) phthalate	ND	0.86	mg/kg
4-Bromophenyl phenyl ether	ND	0.86	mg/kg
Butyl benzyl phthalate	ND	0.86	mg/kg
4-Chloroaniline	ND	1.6	mg/kg
4-Chloro-3-methylphenol	ND	1.6	mg/kg
2-Chlorophenol	ND	0.86	mg/kg
4-Chlorophenyl phenyl ether	ND	0.86	mg/kg
Chrysene	ND	0.86	mg/kg
Dibenz(a,h)anthracene	ND	0.86	mg/kg
Dibenzofuran	ND	0.86	mg/kg
1,2-Dichlorobenzene	ND	0.86	mg/kg
1,3-Dichlorobenzene	ND	0.86	mg/kg
1,4-Dichlorobenzene	ND	0.86	mg/kg
3,3'-Dichlorobenzidine	ND	1.6	mg/kg
2,4-Dichlorophenol	ND	0.37	mg/kg
Diethyl phthalate	ND	0.86	mg/kg
2,4-Dimethylphenol	ND	0.37	mg/kg
Dimethyl phthalate	ND	0.86	mg/kg
4,6-Dinitro- 2-methylphenol	ND	4.1	mg/kg
2,4-Dinitrophenol	ND	4.1	mg/kg
2,4-Dinitrotoluene	ND	0.86	mg/kg
2,6-Dinitrotoluene	ND	0.86	mg/kg
Di-n-octyl phthalate	ND	0.86	mg/kg

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## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-3R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-002 Work Order #....: CQG16102 Matrix.....: SO

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Fluoranthene	ND	0.86	mg/kg
Fluorene	ND	0.86	mg/kg
Hexachlorobenzene	ND	0.86	mg/kg
Hexachlorobutadiene	ND	0.86	mg/kg
Hexachlorocyclopentadiene	ND	0.86	mg/kg
Hexachloroethane	ND	0.86	mg/kg
Indeno(1,2,3-cd)pyrene	ND	0.86	mg/kg
Isophorone	ND	0.86	mg/kg
2-Methylnaphthalene	ND	0.86	mg/kg
2-Methylphenol	ND	0.37	mg/kg
Naphthalene	ND	0.86	mg/kg
2-Nitroaniline	ND	4.1	mg/kg
3-Nitroaniline	ND	4.1	mg/kg
4-Nitroaniline	ND	4.1	mg/kg
Nitrobenzene	ND	0.86	mg/kg
2-Nitrophenol	ND	0.37	mg/kg
4-Nitrophenol	ND	2.0	mg/kg
N-Nitrosodiphenylamine	ND	0.86	mg/kg
N-Nitrosodi-n-propylamine	ND	0.86	mg/kg
Pentachlorophenol	ND	4.1	mg/kg
Phenanthrene	ND	0.86	mg/kg
Phenol	ND	0.37	mg/kg
Pyrene	ND	0.86	mg/kg
1,2,4-Trichlorobenzene	ND	0.86	mg/kg
2,4,5-Trichlorophenol	ND	4.1	mg/kg
Benzyl alcohol	ND	1.6	mg/kg
bis(2-Chloroisopropyl) ether	ND	0.86	mg/kg
2-Chloronaphthalene	ND	0.86	mg/kg
Di-n-butyl phthalate	ND	0.86	mg/kg
4-Methylphenol	ND	0.37	mg/kg
2,4,6-Trichlorophenol	ND	0.37	mg/kg

SURROGATE	PERCENT	RECOVERY
	RECOVERY	LIMITS
2,4,6-Tribromophenol	82	(25 - 144)
2-Fluorobiphenyl	77	(34 - 135)
2-Fluorophenol	73	(25 - 135)
Nitrobenzene-d5	72	(25 - 135)
Phenol-d5	72	(25 - 135)
Terphenyl-d14	83	(32 - 136)

## NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

## PARSONS ENGINEERING SCIENCE, INC.

POSB-3R-12

## GC/MS Semivolatiles

Lot-Sample #: D9B030153-002

Work Order #: CQG16102

Matrix: SO

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Aldol condensation product		14 B	M	mg/kg
Benzene, 1-ethyl-2-methyl-	611-14-3	0.24	M	mg/kg
Benzene, 1,2,3-trimethyl-	526-73-8	0.20	M	mg/kg
1,2,4-Trimethylbenzene	95-36-3	0.87	M	mg/kg
2-Nonadecanone	629-66-3	0.18	M	mg/kg
Eicosane	112-95-8	0.22	M	mg/kg
Cyclotetracosane	297-03-0	0.38	M	mg/kg
1-Eicosanol	629-96-9	0.19	M	mg/kg
2-Pentacosanone	0-00-0	0.34	M	mg/kg
Perylene	198-55-0	2.2	M	mg/kg
Unknown #1	57-20-0	0.21	M	mg/kg
Unknown #2	57-20-0	0.18	M	mg/kg
Unknown #3	57-20-0	0.34	M	mg/kg
Unknown #4	57-20-0	0.18	M	mg/kg
Unknown #5	57-20-0	0.18	M	mg/kg
D-friedoolean-14-ene, 3-methox	14021-23-9	1.7	M	mg/kg
Unknown #6	57-20-0	0.89	M	mg/kg
Unknown #7	57-20-0	0.26	M	mg/kg
Unknown #8	57-20-0	0.58	M	mg/kg
Unknown #9	57-20-0	0.17	M	mg/kg
Naphthalene, 1,2,3,4,4a,5,6,8a	473-13-2	0.22	M	mg/kg
Unknown #10	57-20-0	0.18	M	mg/kg
Unknown #11	57-20-0	0.36	M	mg/kg

NOTE(S) :

M: Result was measured against nearest internal standard assuming a response factor of 1.



## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-4R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-003    Work Order #....: CQG17101    Matrix.....: SO  
 Date Sampled....: 02/02/99 12:50    Date Received...: 02/03/99  
 Prep Date.....: 02/03/99    Analysis Date...: 02/08/99  
 Prep Batch #....: 9034303    Analysis Time...: 16:05  
 Dilution Factor: 1  
 % Moisture.....: 16    Method.....: SW846 8270B

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Acenaphthene	0.56 F	0.83	mg/kg
Acenaphthylene	ND	0.83	mg/kg
Anthracene	0.57 F	0.83	mg/kg
Benzo (a) anthracene	0.45 F	0.83	mg/kg
Benzo (b) fluoranthene	0.21 F	0.83	mg/kg
Benzoic acid	ND	1.9	mg/kg
Benzo (ghi) perylene	ND	0.83	mg/kg
Benzo (a) pyrene	0.24 F	0.83	mg/kg
bis (2-Chloroethoxy) methane	ND	0.83	mg/kg
bis (2-Chloroethyl) ether	ND	0.83	mg/kg
bis (2-Ethylhexyl) phthalate	ND	0.83	mg/kg
4-Bromophenyl phenyl ether	ND	0.83	mg/kg
Butyl benzyl phthalate	ND	0.83	mg/kg
4-Chloroaniline	ND	1.5	mg/kg
4-Chloro-3-methylphenol	ND	1.5	mg/kg
2-Chlorophenol	ND	0.83	mg/kg
4-Chlorophenyl phenyl ether	ND	0.83	mg/kg
Chrysene	0.43 F	0.83	mg/kg
Dibenz (a, h) anthracene	ND	0.83	mg/kg
Dibenzofuran	0.35 F	0.83	mg/kg
1,2-Dichlorobenzene	ND	0.83	mg/kg
1,3-Dichlorobenzene	ND	0.83	mg/kg
1,4-Dichlorobenzene	ND	0.83	mg/kg
3,3'-Dichlorobenzidine	ND	1.5	mg/kg
2,4-Dichlorophenol	ND	0.36	mg/kg
Diethyl phthalate	ND	0.83	mg/kg
2,4-Dimethylphenol	ND	0.36	mg/kg
Dimethyl phthalate	ND	0.83	mg/kg
4,6-Dinitro- 2-methylphenol	ND	3.9	mg/kg
2,4-Dinitrophenol	ND	3.9	mg/kg
2,4-Dinitrotoluene	ND	0.83	mg/kg
2,6-Dinitrotoluene	ND	0.83	mg/kg
Di-n-octyl phthalate	ND	0.83	mg/kg

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## PARSONS ENGINEERING SCIENCE, INC.

Client Sample ID: POSB-4R-12

## GC/MS Semivolatiles

Lot-Sample #....: D9B030153-003 Work Order #....: CQG17101 Matrix.....: SO

PARAMETER	RESULT	REPORTING	
		LIMIT	UNITS
Fluoranthene	1.3	0.83	mg/kg
Fluorene	0.93	0.83	mg/kg
Hexachlorobenzene	ND	0.83	mg/kg
Hexachlorobutadiene	ND	0.83	mg/kg
Hexachlorocyclopentadiene	ND	0.83	mg/kg
Hexachloroethane	ND	0.83	mg/kg
Indeno (1,2,3-cd) pyrene	ND	0.83	mg/kg
Isophorone	ND	0.83	mg/kg
2-Methylnaphthalene	4.0	0.83	mg/kg
2-Methylphenol	ND	0.36	mg/kg
Naphthalene	0.55 F	0.83	mg/kg
2-Nitroaniline	ND	3.9	mg/kg
3-Nitroaniline	ND	3.9	mg/kg
4-Nitroaniline	ND	3.9	mg/kg
Nitrobenzene	ND	0.83	mg/kg
2-Nitrophenol	ND	0.36	mg/kg
4-Nitrophenol	ND	1.9	mg/kg
N-Nitrosodiphenylamine	ND	0.83	mg/kg
N-Nitrosodi-n-propylamine	ND	0.83	mg/kg
Pentachlorophenol	ND	3.9	mg/kg
Phenanthrene	2.7	0.83	mg/kg
Phenol	ND	0.36	mg/kg
Pyrene	1.3	0.83	mg/kg
1,2,4-Trichlorobenzene	ND	0.83	mg/kg
2,4,5-Trichlorophenol	ND	3.9	mg/kg
Benzyl alcohol	ND	1.5	mg/kg
bis (2-Chloroisopropyl) ether	ND	0.83	mg/kg
2-Chloronaphthalene	ND	0.83	mg/kg
Di-n-butyl phthalate	ND	0.83	mg/kg
4-Methylphenol	ND	0.36	mg/kg
2,4,6-Trichlorophenol	ND	0.36	mg/kg

SURROGATE	PERCENT	RECOVERY
	RECOVERY	LIMITS
2,4,6-Tribromophenol	86	(25 - 144)
2-Fluorobiphenyl	77	(34 - 135)
2-Fluorophenol	79	(25 - 135)
Nitrobenzene-d5	70	(25 - 135)
Phenol-d5	79	(25 - 135)
Terphenyl-d14	79	(32 - 136)

## NOTE(S):

F The analyte was identified but the value was below the RL and above the MDL.  
Results and reporting limits have been adjusted for dry weight.

## PARSONS ENGINEERING SCIENCE, INC.

POSB-4R-12

## GC/MS Semivolatiles

Lot-Sample #: D9B030153-003

Work Order #: CQG17101

Matrix: SO

## MASS SPECTROMETER/DATA SYSTEM (MSDS) TENTATIVELY IDENTIFIED COMPOUNDS

PARAMETER	CAS #	ESTIMATED RESULT	RETENTION TIME	UNITS
Aldol condensation product		13 B	M	mg/kg
Tridecane	629-50-5	1.8	M	mg/kg
Tetradecane	629-59-4	3.1	M	mg/kg
Naphthalene, 2,3-dimethyl-	581-40-8	3.7	M	mg/kg
Naphthalene, 2,6-dimethyl-	581-42-0	3.6	M	mg/kg
Unknown #1	57-20-0	2.0	M	mg/kg
Hexatriacontane	630-06-8	3.7	M	mg/kg
Unknown #2	57-20-0	2.1	M	mg/kg
Unknown #3	57-20-0	1.8	M	mg/kg
Pentadecane	629-62-9	5.3	M	mg/kg
Naphthalene, 1,4,6-trimethyl#1	2131-42-2	2.7	M	mg/kg
Naphthalene, 1,4,6-trimethyl#2	2131-42-2	3.9	M	mg/kg
Naphthalene, 2,3,6-trimethyl#1	829-26-5	2.7	M	mg/kg
Naphthalene, 1,6,7-trimethyl-	2245-38-7	1.9	M	mg/kg
Naphthalene, 2,3,6-trimethyl#2	829-26-5	2.1	M	mg/kg
Naphthalene, 2,3,6-trimethyl#3	829-26-5	2.2	M	mg/kg
Hexadecane #1	544-76-3	5.2	M	mg/kg
Unknown #4	57-20-0	2.1	M	mg/kg
Unknown #5	57-20-0	2.0	M	mg/kg
Unknown #6	57-20-0	4.5	M	mg/kg
[1,1'-Biphenyl]-4-carboxaldehy	3218-36-8	2.1	M	mg/kg
Heptadecane	629-78-7	5.8	M	mg/kg
Pentadecane, 2,6,10,14-tetrame	1921-70-6	3.1	M	mg/kg
9H-fluorene, 2-methyl- #1	1430-97-3	2.1	M	mg/kg
9H-fluorene, 2-methyl- #2	1430-97-3	2.6	M	mg/kg
Octadecane #1	593-45-3	4.4	M	mg/kg
Octadecane #2	593-45-3	2.5	M	mg/kg
Hexadecane #2	544-76-3	2.1	M	mg/kg
Nonadecane	629-92-5	3.0	M	mg/kg
Eicosane	112-95-8	2.2	M	mg/kg

## NOTE(S):

M: Result was measured against nearest internal standard assuming a response factor of 1.

Sample Receiving Checklist

Lot #: D9B030153 Date/Time Received: 0900 2/3/99

Company Name & Sampling Site: Parsons

\*Cooler #(s): \_\_\_\_\_

Temperatures: 2.8 \_\_\_\_\_

Unpacking & Labeling Check Points:

- | N/A                                 | Yes                                 | No                                  |                                                                    | Initials   |
|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------------------------------------|------------|
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 1. Radiation checked, record if reading > 0.5 mR/hr. (_____ mR/hr) | <u>1/0</u> |
| <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 2. Cooler seals intact.                                            |            |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 3. Chain of custody present.                                       |            |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 4. Bottles broken and/or are leaking, comment if yes.              |            |

PHOTOGRAPH BROKEN BOTTLES

- |                                     |                                     |                                     |                                                                                                |  |
|-------------------------------------|-------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 5. Containers labeled, comment if no.                                                          |  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 6. pH of all samples checked and meet requirements, note exceptions.                           |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 7. Chain of custody includes "received by" and "relinquished" by signatures, dates, and times. |  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 8. Receipt date(s) > 48 hours past the collection date(s)? If yes, notify PA/PM.               |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 9. Chain of custody agrees with bottle count, comment if no.                                   |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 10. Chain of custody agrees with labels, comment if no.                                        |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 11. VOA samples filled completely, comment if no.                                              |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 12. VOA bottles preserved, check for labels.                                                   |  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 13. Did samples require preservation with sodium thiosulfate?                                  |  |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 14. If yes to #12, did the samples contain residual chlorine?                                  |  |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | 15. Sediment present in "D," dissolved, bottles.                                               |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | 16. Are analyses with short holding times requested? <u>1 week TAT for BNA's.</u>              |  |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | 17. Is extra sample volume provided for MS, MSD or matrix duplicates?                          |  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 18. Multiphase samples present? If yes, comment below.                                         |  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | 19. Any subsampling for volatiles? If yes, list samples.                                       |  |

PHOTOGRAPH MULTIPHASE SAMPLES

- |                                     |                          |                          |                                                                  |  |
|-------------------------------------|--------------------------|--------------------------|------------------------------------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 20. Clear picture taken, labeled, and stapled to project folder. |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 21. Subcontract COC signed and sent with samples to bottle prep? |  |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | 22. Was sample labeling double checked by a second person?       |  |

Document any problems or discrepancies and the actions taken to resolve them on a Condition Upon Receipt Anomaly Report (CUR)





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**Case Narrative**

**SDG 123874**

12/31/98

**Client:** Parsons Engineering Sciences, Inc.  
1700 Broadway, Suite 900  
Denver, CO 80290

**Client Project Number:** 731854.04000

**Matrix:** Water/Soil

**Laboratory Project Number:** 8639

**Number of Samples:** 1 Water/1 Soil

**Date Received:** 12/11/98

**Date Collected:** 12/10/98

**Sample Receipt**

One water sample and one soil sample were received on 12/11/98 for MADEP VPH and EPH analysis.

**VPH**

The samples submitted for VPH analysis exhibited acceptable surrogate recoveries. Aqueous matrix spike/matrix spike duplicate (MS/MSD) analysis was conducted on sample 98POMP8A. Soil MS/MSD analysis was conducted on a sample from another Parsons's delivery group. All MS/MSD recoveries and relative percent difference (RPD) values were acceptable for both MS/MSD pairs. The laboratory control samples (LCS) associated with each matrix, were within control. All instrument calibration was within method specified limits.

**EPH**

The samples submitted for EPH analysis exhibited acceptable surrogate recoveries. Aqueous MS/MSD analysis was conducted on sample 98POM8-A. Soil sample MS/MSD analysis was conducted on sample 98POSB2-12. MS and MSD recoveries for the aqueous matrix were outside of acceptable limits for C9-C18 aliphatic fraction in the MS sample and the C9-C18 aliphatic and C11-C22 aromatic fractions in the MSD sample. RPD values exceeded limits for the C9-C18 aliphatic fraction, C19-C36 aliphatic fraction and C11-C22 aromatic fractions. All soil MS/MSD recoveries and RPD values were outside acceptable limits due to the high concentration of all fractions in the native sample. The LCSs associated each matrix exhibited acceptable recovery of the spiked fuel standard and the data has been reported.

Paula Watts, MS  
Technical Services  
Specialized Assays

000001



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## SPECIALIZED ASSAYS

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000002

SAMPLE NO.

98POMP8A

Contract: \_\_\_\_\_

Site: \_\_\_\_\_

Location: \_\_\_\_\_

SDG 123874

Lab Sample ID: 156416

Lab File ID: 1215HP23.041

Date Received: 12/11/98

Date Analyzed: 12/16/98

ID: 0.53 (mm)

Dilution Factor: 10.0

Soil Extract Volume: \_\_\_\_\_ (uL)

Soil Aliquot Volume: \_\_\_\_\_ (uL)

**Concentration Units:**

(ug/L or ug/Kg)

ug/L

**Q**

CAS No.

Compound

[illegible]
$$\begin{array}{l} C9-C18 \quad 379 = 2,689 \\ C11-C22 \quad 1022 = 2,022 \end{array}$$

FORM I VOA

3/90

000007



1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POMP8-A ALI

Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_

SDG # 123874 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_

Matrix: (soil/water): WATER Lab Sample ID: 156416 ALI

Sample (wt/vol): 1000 (g/mL) \_\_\_\_\_ mL Lab File ID: 1214SH.022

Level: (low/med) LOW Date Recieved: 12/11/98

%Moisture: non dec. Date Analyzed: 12/15/98

GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 1

Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	Q
	C9-C18 ALIPHATIC	379	
	C19-C36 ALIPHATIC	100	U

000160

1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POMP8-A ARO

Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_  
 SDG # 123874 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_  
 Matrix: (soil/water): WATER Lab Sample ID: 156416 ARO  
 Sample (wt/vol): 1000 (g/mL) \_\_\_\_\_ mL Lab File ID: 1214SH.023  
 Level: (low/med) LOW Date Recieved: 12/11/98  
 %Moisture: non dec. Date Analyzed: 12/15/98  
 GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 1  
 Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	Q
	C11-C22 AROMATIC	1022	

000161

98POSB2-12

Contract: \_\_\_\_\_

Location: \_\_\_\_\_

SDG 123874

Lab Sample ID: 156418

Lab File ID: 1215HP23.028

Date Received: 12/11/98

Date Analyzed: 12/16/98

Dilution Factor: 5000.0

Soil Aliquot Volume: \_\_\_\_\_ (uL)

**Concentration Units:**

Compound

(ug/L or ug/Kg)

mg/Kg

**Q**

[illegible]

C9-C18 1,790 = 3550  
C11-C22 1,410 = 1,914

FORM I VOA

3/90

000081

1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POSB2-12 ALI

Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_  
 SDG # 123874 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_  
 Matrix: (soil/water): SOIL Lab Sample ID: 156418 ALI  
 Sample (wt/vol): 10 (g/mL) g Lab File ID: 1216SH.081  
 Level: (low/med) LOW Date Recieved: 12/11/98  
 %Moisture: non dec. 8 Date Analyzed: 12/19/98  
 GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 1  
 Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	Q
	C9-C18 ALIPHATIC	1790000	
	C19-C36 ALIPHATIC	356000	

000232

1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POSB2-12 ARO

Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_  
 SDG # 123874 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_  
 Matrix: (soil/water): SOIL Lab Sample ID: 156418 ARO  
 Sample (wt/vol): 10 (g/mL) g Lab File ID: 1216SH.082  
 Level: (low/med) LOW Date Recieved: 12/11/98  
 %Moisture: non dec. 8 Date Analyzed: 12/19/98  
 GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 10  
 Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	Q
	C11-C22 AROMATIC	1410000	

000233

# Cooler Receipt Form

Client: Pavson

Cooler Received On: 10/11 And Opened On: 10/11/98 By: Pat R. Buckner

RLR  
(Signature)

1. Temperature of Cooler when opened \_\_\_\_\_
2. Were custody seals on outside of cooler and intact?..... ☒ Yes No  
a. If yes, what kind and where: Yes
3. Were custody papers inside cooler?..... ☒ Yes No
4. Were custody papers properly filled out (ink, signed, etc)?..... ☒ Yes No
5. Did you sign the custody papers in the appropriate place?..... ☒ Yes No
6. What kind of packing material was used? bubble wrap
7. Was sufficient ice used (if appropriate)?..... ☒ Yes No
8. Did all bottles arrive in good condition (unbroken)?..... ☒ Yes No
9. Were all bottle labels complete (#, date, signed, pres, etc)?..... ☒ Yes No
10. Did all bottle labels and tags agree with custody papers?..... ☒ Yes No
11. Were correct bottles used for the analysis requested?..... ☒ Yes No
12. If present, were VOA vials checked for absence of air bubbles and noted if found?.. ☒ Yes No
13. Was sufficient amount of sample sent in each bottle?..... ☒ Yes No
14. Were correct preservatives used?..... ☒ Yes No
15. Corrective action taken, if necessary:

a. Name of person contacted: \_\_\_\_\_

b. Date \_\_\_\_\_

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.  
P.O. Box 40566  
Nashville, TN 37204-0566  
Phone 1-615-726-0177

PARSONS ENGINEERING SCIENCE 8639

1700 BROADWAY STE 900  
DENVER, CO 80290

**CHAIN OF CUSTODY**

Project Number: 731854.04000				Sampler: T. DRAGOO				<div>MADEP-VPH (MS) MADEP-VPH (MS) MADEP-VPH (MS) MADEP-EPH (MS) MADEP-EPH (MS) MADEP-EPH (MS)</div> <div>Analysis Requested</div>							
Project Name: AFCEE RBLA				SAE Quota:											
Lab No.	Field Number	Date	Time	Matrix	Grab	Comp	Bottles								
98POMP8-A	98-A156416	12/10/98	1530	Water				X	X	X	X	X	X		
98POSB2-12	98-A156418	12/10/98	1130	Soil				X			X				
TEMP BLANK 40C															
TRIP BLANK															
98-A156417															
Relinquished by: [Signature]		D/T: 12/10/98 1900	Received by:		D/T:	Relinquished by:		D/T:	Received by:		D/T:				
Relinquished by:		D/T:	Received by:		D/T:	Relinquished by:		D/T:	Received by: [Signature]		D/T: 12/11/98 2100				

Cooler Temperature When Received: 40C

**SPECIAL INSTRUCTIONS:**

Laboratory Project Number: 123874

Seals Intact?

Fed-X Air Bill Number:



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**Case Narrative**

**SDG 124030**

**12/31/98**

**Client:** Parsons Engineering Sciences, Inc.  
1700 Broadway, Suite 900  
Denver, CO 80290

**Client Project Number:** NA

**Matrix:** Soil

**Laboratory Project Number:** 8639

**Number of Samples:** 1

**Date Received:** 12/12/98

**Date Collected:** 12/11/98

**Sample Receipt**

One soil sample was received on 12/12/98 for MADEP VPH and EPH analysis.

**VPH**

The sample submitted for VPH analysis exhibited acceptable surrogate recoveries. Matrix spike/matrix spike duplicate (MS/MSD) analysis was conducted on a sample from another Parsons's delivery group. All MS/MSD recoveries and relative percent difference (RPD) values were acceptable for the MS/MSD analysis. The laboratory control sample (LCS) was within control. All instrument calibration was within method specified limits.

**EPH**

The sample submitted for EPH analysis exhibited acceptable surrogate recoveries. MS/MSD analysis was conducted on sample 98POSB4-12. All MS and MSD recoveries were acceptable. The RPD value exceeded limits for the C9-C18 aliphatic fraction. The LCS exhibited acceptable recovery of the spiked fuel standard.

Paula Watts, MS  
Technical Services  
Specialized Assays

000001





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## SPECIALIZED ASSAYS

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	Results and Summary Data	<u>000084</u>
	Raw Data	<u>000113</u>
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000002

SAMPLE NO.

98POSB4-12

Contract: \_\_\_\_\_

Site: \_\_\_\_\_

Location: \_\_\_\_\_

SDG 124030

## SOIL

## 5.0

(g/mL) g

N/A

0

ID: 0.53 (mm)

(uL)

**: 157079**

Lab File ID: 1215HP23.034

: 12/12/98

12/16/98

500.0

•

mg/Kg

**Q**

$$\begin{array}{r} C9-C18 \cdot 10.8 = 1210 \\ C11-C22 \cdot 10.8 = 471 \end{array}$$

3/90

000006

1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POSB4-12 ALI

Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_  
 SDG # 124030 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_  
 Matrix: (soil/water): SOIL Lab Sample ID: 157079 ALI  
 Sample (wt/vol): 10 (g/mL) g Lab File ID: 1216SH.079  
 Level: (low/med) LOW Date Recieved: 12/12/98  
 %Moisture: non dec. 7 Date Analyzed: 12/19/98  
 GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 1  
 Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	ug/Kg
	C9-C18 ALIPHATIC		10800
	C19-C36 ALIPHATIC		10800

000085

1A  
PETROLEUM HYDROCARBON ANALYSIS DATA SHEET

SAMPLE NO.

98POSB4-12 ARC

Lab Name: SPECIALIZED ASSAYS Contract: \_\_\_\_\_

SDG # 124030 Site: \_\_\_\_\_ Location: \_\_\_\_\_ Group: \_\_\_\_\_

Matrix: (soil/water): SOIL Lab Sample ID: 157079 ARO

Sample (wt/vol): 10 (g/mL) g Lab File ID: 1216SH.080

Level: (low/med) LOW Date Recieved: 12/12/98

%Moisture: non dec. 7 Date Analyzed: 12/19/98

GC Column: DB-1 ID: 0.32 (mm) Dilution Factor: 1

Soil Extract Volume: 1000 (uL) Soil Aliquot Volume: \_\_\_\_\_ (uL)

CAS No.	Compound	Concentration Units:	
		(ug/L or ug/Kg)	ug/Kg
	C11-C22 AROMATIC	10800	Q
			U

000086

# Cooler Receipt Form

Client: PANSONS

Cooler Received On: 12/12/98 And Opened On: 12/12/98 By: Paul R. Buckingham

Paul R. Buckingham  
(Signature)

1. Temperature of Cooler when opened 40c
2. Were custody seals on outside of cooler and intact?.....☒ Yes ☐ No
- a. If yes, what kind and where: 2 sent back
- b. Were the signature and date correct?.....☒ Yes ☐ No
3. Were custody papers inside cooler?.....☒ Yes ☐ No
4. Were custody papers properly filled out (ink, signed, etc)?.....☒ Yes ☐ No
5. Did you sign the custody papers in the appropriate place?.....☒ Yes ☐ No
6. What kind of packing material was used? bubble wrap
7. Was sufficient ice used (if appropriate)?.....☒ Yes ☐ No
8. Did all bottles arrive in good condition (unbroken)?.....☒ Yes ☐ No
9. Were all bottle labels complete (#, date, signed, pres, etc)?.....☒ Yes ☐ No
10. Did all bottle labels and tags agree with custody papers?.....☒ Yes ☐ No
11. Were correct bottles used for the analysis requested?.....☒ Yes ☐ No
12. If present, were VOA vials checked for absence of air bubbles and noted if found?.....☒ Yes ☐ No
13. Was sufficient amount of sample sent in each bottle?.....☒ Yes ☐ No
14. Were correct preservatives used?.....☒ Yes ☐ No
15. Corrective action taken, if necessary:

a. Name of person contacted: \_\_\_\_\_

b. Date: \_\_\_\_\_

000004

# Chain of Custody Record

124030

QUA-4124 0797

Client **Parsens Eng Science, Inc**  
 Address **1700 Broadway Suite 900**  
**Denver**  
 State **CO** Zip Code **80202**  
 Project Name **AFCEE RBLA Investigation**  
 Contract/Purchase Order/Quote No.

Project Manager

**John Hicks**

Telephone Number (Area Code)/Fax Number

**303-831-8100**

Site Contact

**T. Driscoll**

Carrier/Waybill Number

Lab Contact

**John M. Lell**

Date **12/11/98**

Chain of Custody Number **135038**

Page **1** of **1**

Analysis (Attach list if more space is needed)

Special Instructions/  
Conditions of Receipt

Sample I.D. No. and Description  
(Containers for each sample may be combined on one line)

**98POS64-12**

**Temperature blank**

Date

**12-11-98**

Time

**11:00**

Matrix

**X**

Containers & Preservatives

**NaOH**

**NaOH**

**HCl**

**HNO3**

**H2SO4**

**Unpres.**

**Aqueous**

**Soil**

**Sed.**

**NaOH**

**ZnAc**

**NaOH**

**HCl**

**HNO3**

**H2SO4**

**Unpres.**

**Aqueous**

**Soil**

**Sed.**

**98-A157079**

**407 Jm, ENCORE SAMP.**

Possible Hazard Identification

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Turn Around Time Required

☐ 24 Hours ☒ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other

Sample Disposal

☐ Return To Client ☐ Disposal By Lab ☐ Archive For

Months

(A fee may be assessed if samples are retained longer than 3 months)

QC Requirements (Specify)

**24 hour hold on VPH 11.1**

1. Received By

Date **12/11/98** Time **1900**

2. Received By

Date Time

3. Received By

Date Time

**DRB**

Date **12/12/98** Time **9:00**

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

**APPENDIX B**  
**DATA FROM PREVIOUS INVESTIGATIONS**

**BIOVENTING  
PERFORMED BY  
PARSONS ENGINEERING SCIENCE 1995-1997**



June 13, 1997

Ms. Jo Ann Mette  
Environmental Contracts Branch  
U.S. Army Corps of Engineers, Savannah District  
100 West Oglethorpe Avenue  
P. O. Box 889  
Savannah, GA 31401

Subject: Interim System Effectiveness Report for Bioventing Pilot Study  
at IRP Site ST-08, Pope Air Force Base, North Carolina  
Delivery Order No. 13  
Contract No. DACA21-94-D-0059  
Project Number: TMKH977001A

Dear Ms. Mette:

Parsons Engineering Science, Inc. (Parsons ES) completed the May 1997 site monitoring, sampling, and testing activities of the Bioventing Pilot Study at Installation Restoration Program (IRP) Site ST-08, Pope Air Force Base (AFB), North Carolina under Delivery Order No. 13, Contract No. DACA21-94-D-0059. Upon completion of the field activities and receipt of analytical results, Parsons ES prepared this Interim System Effectiveness Report in accordance with the Delivery Order Statement of Work. This letter report contains a summary of past site activities, all historical soil and soil gas sampling results and field measurements, and respiration and permeability test data associated with the operating bioventing system.

## SITE LOCATION AND HISTORY

IRP Site ST-08 is a former fuel oil storage facility located near the center of the Base between Taxiway B and Boxcar Street and adjacent to Tank Creek. Figure 1 shows the location of Pope AFB and the test site on a U.S.G.S. topographic map. Site ST-08 was previously utilized as a #2 fuel oil (heating oil) storage and distribution facility for the Base. The site utilized four 25,000-gallon steel underground storage tanks (USTs), which were installed in the early- to mid-1970's.

The four USTs, ancillary piping, and fuel dispensers were excavated and removed from the site in November 1992 after the UST system failed integrity testing. Contaminated soil was encountered during the UST system removal. The Base reported that floating fuel (free product) was observed on water that collected in the open excavation and that the fuel-contaminated soil excavated during the UST closure was placed back into the excavation after the USTs were removed. It was also reported that the UST removal contractor placed a layer of thick plastic in the hole at a depth of about 15 feet below ground surface (bgs) prior to backfilling. Figure 2 shows a site plan of Site ST-08 with the former UST system location.



## INITIAL TESTING ACTIVITIES

In August 1994, Parsons ES conducted a preliminary soil gas/soil boring survey at Site ST-08 to evaluate the extent of contamination and to determine if the site was a good candidate site for bioventing. This work was done under contract to the Air Force Center for Environmental Excellence (AFCEE). Results of the soil survey are reported in *Part I: Bioventing Test Work Plan For IRP ST-08 Former Fuel Oil Storage Facility, Pope AFB, North Carolina* (September 1994). After this preliminary survey, the U.S. Army Corps of Engineers (COE) was contracted to install two 4-inch diameter monitoring wells (HF-1 and HF-2) in the vicinity of the former UST excavation to check groundwater quality. In September 1994, the COE conducted a field screening of the site using a cone-penetrometer (CPT) coupled with a laser-induced fluorescence (LIF) probe. Select CPT/LIF screening locations and the monitoring wells are shown on Figure 2.

During February 1995, Parsons ES installed two air injection vent wells (VWs), and four permanent vapor/pressure monitoring points (MPs). A 50-foot VW spacing was used to obtain coverage throughout the contaminated area. Figure 2 shows the VW and MP locations relative to existing and previous site features.

During installation of the VW and MP boreholes, Parsons ES collected soil samples near the screened intervals of three VWs/MPs [e.g., VW1 (10-foot depth), MPA (9.7-foot depth), and MPD (8.7-foot depth)] for laboratory analyses. These samples were selected for laboratory analyses because they exhibited the highest field-screened hydrocarbon concentrations. Periodic soil sample collection allows a direct comparison between soil and soil gas concentrations, and allows recurrent assessment of soil remediation progress throughout the project. Soil gas SUMMA<sup>®</sup> canisters also were collected from the same three locations for comparative analyses. Historical soil and soil gas analytical results and historical soil gas screening results for these three locations are provided in Table 1.

In March 1995, Parsons ES conducted two air permeability tests and an *in situ* respiration test prior to operating the pilot scale system. Prior to initiating any air injection, all MPs were purged until oxygen concentrations had stabilized and then initial oxygen (O<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), and total volatile hydrocarbons (TVH) concentrations were measured using portable gas analyzers. Historical soil gas screening results are summarized in Table 2. Test procedures and results for each of the tests and sampling methodologies are discussed in *Part II: Draft Bioventing Pilot Test Results Report, IRP Site ST-08, Former Fuel Oil Storage Facility, Pope AFB, North Carolina* (May 1995). Air permeability test data are provided in Tables 3a and 3b.

Parsons ES then performed a respiration test at the site. This test consisted of injecting air into the VWs and MPs using small-portable blowers to reoxygenate the subsurface soils. After approximately 12 hours of injecting air into the VWs and MPs, Parsons ES turned off the blowers and measured oxygen utilization within the VWs and MPs over a several day period until adequate oxygen decreases were observed within the VWs and MPs. Respiration test procedures and results are discussed in *Part II: Draft Bioventing Pilot Test Results Report, IRP Site ST-08, Former Fuel Oil Storage Facility, Pope AFB, North Carolina* (May 1995). A summary of historical respiration test results and calculated *in situ* biodegradation rates is provided in Table 4.

## LONG-TERM PILOT SYSTEM DESIGN, OPERATION, AND REMEDIAL SYSTEM OBJECTIVES

Parsons ES designed and installed a long-term pilot test system at the site after evaluating the initial soil gas data, and permeability and respiration test results. The installed system utilizes a single blower contained in a weather-proof enclosure and two vertical air injection wells (VW-1 and VW-2). The system utilizes an oil-less rotary vane blower manufactured by Gast Manufacturing Corporation that is capable of sustaining a flow rate of 50 standard cubic feet per minute (scfm) at 70 inches of water pressure (inches H<sub>2</sub>O). The system began operating on October 31, 1995.

The long-term pilot test had four primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil depth; 2) to determine the rate at which indigenous microorganisms will degrade the fuel when stimulated by oxygen-rich soil gas, 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to below regulatory standards; and 4) to initiate soil bioremediation activities while additional contaminant assessment and remedial design information was being collected.

## CURRENT SCOPE OF WORK

In February 1997, Parsons ES was contacted by the US Army COE, Savannah District (under Delivery Order No. 13, Contract No. DACA21-94-D-0059) to perform the following four tasks at the site.

Task No.	Description	Proposed Dates	Status
1	Routine System Operations and Maintenance (O&M) to ensure proper blower operation.	Weekly site visits	Performed on a weekly basis
2	i) Quarterly soil gas screening	April 1997 July 1997 October 1997 January 1998 April 1998 July 1998 September 1998	Yes No No No No No No
	ii) Annual respiration tests	April 1997 August 1998	Yes No
	iii) Annual soil gas sampling	May 1997 September 1998	Yes No
3	System Effectiveness Reporting	June 1997 September 1998	Yes No
4	Data Management - input data into IRPIMS database.	On-going	Not yet performed

## SUMMARY OF HISTORICAL BIOVENTING TEST RESULTS

### Analytical Results of Soil Samples

A summary of historical soil and soil gas analytical results are provided in Tables 1 and 2. During February 1995, Parsons ES collected soil samples adjacent to vent well VW-1 (10 ft bgs) and monitoring points MP-A (9.7 ft bgs) and MP-D (8.7 ft bgs). Baseline soil hydrocarbon results (Table 1) indicated that the reportable benzene, toluene, ethylbenzene, and total xylenes (BTEX) concentrations were below detectable limits. Similar results were shown by the May 1997 sampling results. The absence of BTEX at the site is expected because fuel oil only contains limited quantities of these compounds.

Laboratory results for the total recoverable petroleum hydrocarbon (TRPH) analyses are also in Table 1. TRPH results from locations VW1-10 and MPA-9.7 both decreased by approximately 22 %; TRPH at MPD-8.7 decreased by about 50% in approximately three months. These data indicate the potential variability of samples collected using a hand auger. Also, the limited number of samples (i.e., three) reduces the data reliability. As a result, Pope AFB will need to collect additional soil quality data in order to more thoroughly assess soil contamination throughout the entire site.

### SUMMA<sup>®</sup> Canister Results

Soil gas samples are used on bioventing sites to evaluate remediation progress of the hydrocarbon fraction capable of partitioning into the soil gas phase. Therefore, SUMMA<sup>®</sup> canister soil gas samples were collected from locations VW1-10, MPA-9.7, and MPD-8.7. SUMMA<sup>®</sup> canister samples were first collected on February 13, 1995 prior to performing any bioventing activities. After the system was turned on, additional samples then were collected on March 1, 1996 and May 9, 1997. Prior to collecting any SUMMA<sup>®</sup> canisters, the bioventing system was turned off for a 30-day period to allow for equilibration of hydrocarbons between the soil and soil gas phases. Results from such analyses indicate the presence, or absence, of hydrocarbons adsorbed to site matrix soils that can partition into the soil gas phase (i.e., quantity of volatile hydrocarbons that remain in the subsurface).

The SUMMA<sup>®</sup> canister results collected on March 13, 1995 (Table 1) indicate that only minimal BTEX concentrations were present in the soil gas initially. This is because BTEX is only a small component of fuel oil. The results from the May 9, 1997 sampling event indicate that the bioventing system has reduced the soil gas BTEX concentrations to below detectable concentrations for all samples.

The March 13, 1995 SUMMA<sup>®</sup> canister results indicate that total hydrocarbon concentrations (Table 1) were initially high for all three samples. Substantial remediation progress was made within the first six months of system operation, as indicated by the March 1, 1996 SUMMA<sup>®</sup> canister results. Additional decreases were observed after 16 months of operation, as indicated by the May 9, 1997 data.

### Soil Gas Results

Hand-held instruments were used periodically throughout the project to determine O<sub>2</sub>, CO<sub>2</sub>, and TVH concentrations within site VWs and MPs. A summary of historical soil gas readings are

provided in Table 2. Results indicate significant changes in O<sub>2</sub>, CO<sub>2</sub>, and TVH concentrations over the project duration. Initially, TVH was very high (typically >10,000 ppmv), which supplied a substantial carbon (energy) source for aerobic and facultative hydrocarbon-degrading microorganisms that are naturally present in soils.

On October 31, 1995 (prior to system operation), the soil gas O<sub>2</sub> concentrations were low (0.2% to 3.1%) because the soil microorganisms utilized the oxygen naturally present in soil to aerobically degrade the released fuels. Because CO<sub>2</sub> is a waste product of aerobic respiration, CO<sub>2</sub> concentrations O<sub>2</sub> and CO<sub>2</sub> concentrations at that time were high (11.8% to 21%). However, within three months of operating the bioventing system, changes in O<sub>2</sub> and CO<sub>2</sub> concentrations were observed in most of the MPs. This suggests that the bioventing system is supplying enough O<sub>2</sub> to overcome the deficit posed by microbial degradation of the petroleum hydrocarbons and is supplying enough air flow to reduce CO<sub>2</sub> concentrations. Less substantial changes were observed at MP-D. This may be due to variations in soil lithology or soil compaction differences that result in less air flow to this area.

#### **Oxygen Radius of Influence**

During operation of the system, O<sub>2</sub> levels increased in most MPs and MWs. The smallest O<sub>2</sub> increases were observed at MP-D, located approximately 30 feet from the closest vent well. A substantial O<sub>2</sub> increase was observed at HF-2, which is located 39 feet from VW-2. The ranges for O<sub>2</sub> increases are likely due to variations in soil lithology and compaction across the site. However, these data indicate that the effective radius of influence may range from 30 feet to more than 40 feet.

#### ***In-Situ* Respiration Tests**

Parsons ES performed *in-situ* respiration tests at IRP Site ST-08 in March 1995 to compare baseline (initial) biodegradation rates to subsequent rates obtained throughout the project. Additional respiration tests were performed in March 1996 and April 1997. Rate calculation results from these tests are provided in Table 4. Changes in biodegradation rates are graphically illustrated in Figure 3. Calculated hydrocarbon biodegradation rates within four VWs/MPs were initially high: 1,700 mg/Kg/year at VW-2 and MPC-4.7 and 1,400 mg/Kg/year at MPB-9.2 and MPD-8.7. Data from the other six locations ranged from 440 to 940 mg/Kg/year. The apparent biodegradation rates for the next two respiration tests were similar. The March 1996 rates ranged from 79 to 560 mg/Kg/year and May 1997 rates ranged from 13 to 487 mg/Kg/year, indicating that hydrocarbon degradation is still occurring at the site.

#### **Air Permeability Test Results**

In March 1995, Parsons ES conducted two air permeability tests prior to operating the pilot scale system. During these short-term tests, Parsons ES observed a small pressure response (0.03 inches of water) in monitoring point MPC-4.7, which is located over 40 feet from the vent wells. The air permeability (k) values obtained from these two tests ranged from 1.1 to 3.1 Darcys. Air permeability test data is provided in Tables 3a and 3b.

Additional air permeability tests were not performed during the project. However, historical system operating conditions and soil pressure responses in monitoring points are provided in



Table 5. During the most recent measurement, a pressure response of over 2 inches H<sub>2</sub>O and soil gas O<sub>2</sub> were observed in a monitoring point (MPD-4.7) located at a 40-foot radius from the nearest vent well. This pressure response and the changes in soil gas readings over time (Table 2) suggest that the bioventing system is able to promote *in situ* degradation of hydrocarbons at a substantial distance from the vent wells.

### Liquid Levels in Monitoring Wells and Vent Wells

Periodic groundwater depths and free product thicknesses were measured in monitoring wells HF-1 and HF-2 and vent wells VW-1 and VW-2 throughout the project (Table 6). Apparent product thickness in monitoring wells HF-1 and HF-2 and vent wells VW-1 and VW-2 have increased throughout the project. These increases are likely attributed to liquid fuel being gradually released from the subsurface soils over time and then accumulating on the groundwater surface. Due to its design, the bioventing system will have limited beneficial, or detrimental, effects to the mobile free-product that remains in the subsurface.

### CONCLUSIONS

Substantial bioventing progress was made during the first six months of long-term pilot scale system operation. The bioventing system is capable of promoting O<sub>2</sub> increases in the vadose zone of the pilot test study area, allowing site remediation to proceed naturally via aerobic biodegradation. An adequate air supply is being provided to the pilot test study area as evident by the increasing O<sub>2</sub> concentrations and decreasing CO<sub>2</sub> and TVH concentrations in soil gas. Biodegradation rates have remained steady over the entire project duration, except at four locations where apparent biodegradation rates were initially very high. Also, the system has been effective at reducing soil and soil gas TPH and BTEX compounds in the pilot test study area.

The SUMMA<sup>®</sup> canister soil gas results show a substantial decrease in total hydrocarbon concentrations within MPs within the study area. This suggests that the remaining fuel oil components have less affinity for the soil-gas phase because the volatile components have been lost due to biodegradation and volatilization promoted by bioventing. Even though the soil hydrocarbon analyses do not indicate substantial TRPH decreases in soils, the residual fuel at the site poses substantially less risk due to loss of the more mobile (i.e., volatile) fractions.

### RECOMMENDATIONS

The existing long-term bioventing pilot test system is operating in accordance with its intended design by achieving O<sub>2</sub> concentration increases and CO<sub>2</sub> and TVH concentration decreases in soil gas within the study area. The existing system, coupled with the planned weekly site checks and quarterly sampling regime, is relatively inexpensive to operate, as compared to the cost of designing and installing an alternative treatment system. Therefore, Parsons ES recommends that the bioventing system continue to operate in the study area until a free-product removal system can be installed, or until it can be determined, through site monitoring, that the system is no longer effectively reducing the residual hydrocarbons present at the site. Data is not available at this time to evaluate remediation progress within soil outside of the study area. Therefore, Parsons ES also recommends that Pope AFB further assess the outer boundaries of the study area to more thoroughly evaluate the full extent of contamination at the site.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.



Donald R. Malone, P.E.  
Project Engineer



Penny Mascaro  
Project Manager

DRM:mp

ENCLOSURES

cc: Robert Byrd, IRP Manager, Pope AFB  
Parsons Project File 731381.03000

## TABLES

Table 1	Historical Soil and Soil Gas Analytical Results
Table 2	Historical Soil Gas Readings
Table 3a	Initial Pressure Response - Air Permeability Test #1
Table 3b	Initial Pressure Response - Air Permeability Test #2
Table 4	Respiration and Fuel Biodegradation Rates
Table 5	Historical Soil Gas Pressure Readings
Table 6	Historical Groundwater Levels and Free Product Measurements



Table 1

**Historical Soil and Soil Gas Analytical Results**  
**IRP Site ST-08**  
**Former Fuel Oil Storage Facility**  
**Pope AFB, North Carolina**

Soil Hydrocarbon Results							Soil Gas Results <sup>a/</sup>				Summa Canister Results <sup>b/</sup>					
Date (mm/dd/yr)	Benzene (mg/Kg) <sup>c/</sup>	Toluene (mg/Kg)	Ethyl- benzene (mg/Kg)	Xylenes (mg/Kg)	TPH <sup>d/</sup> (mg/Kg)	TRPH <sup>e/</sup> (mg/Kg)	Date (mm/dd/yr)	O <sub>2</sub> (%)	CO <sub>2</sub> (%)	TVH <sup>f/</sup> (ppmv) <sup>e/</sup>	Date (mm/dd/yr)	Benzene (ppmv)	Toluene (ppmv)	Ethyl- benzene (ppmv)	Xylenes (ppmv)	Total Hydro- carbons <sup>g/</sup> (ppmv)
Vent Well VW1-10 <sup>i/</sup>																
2/13/95	<0.057	<0.057	<0.057	<0.11	NS <sup>h/</sup>	4,120	3/13/95	0.0	12.1	>10,000	3/13/95	<0.57	68	4.8	14	3,400
5/9/97	<0.028	<0.028	<0.028	<0.028	2,200	3,200	2/28/96	21.0	NS	12	3/1/96	0.049	0.11	0.017	0.083	14
											5/9/97	<0.11	<0.11	<0.11	<0.22	12
Monitoring Point MPA-9.7 <sup>i/</sup>																
2/13/95	<0.057	<0.057	<0.057	<0.11	NS	4,160	3/13/95	4.0	10.8	>10,000	3/13/95	<0.13	3.6	3.3	8.1	5,000
5/9/97	<0.029	<0.029	<0.029	<0.029	1,400	3,200	10/31/95	2.3	15.5	NS	3/1/96	0.51	1.2	0.082	1.4	290
							1/17/96	18.3	2.0	NS	5/9/97	<0.15	<0.15	<0.15	<0.30	270
							2/28/96	20.0	NS	100						
							4/8/97	18.0	1.2	78						
Monitoring Point MPD-8.7 <sup>i/</sup>																
2/13/95	<0.058	<0.058	<0.058	<0.012	NS	1,290	3/13/95	10.5	9.9	>10,000	3/13/95	<0.34	2.8	3.9	9	3,100
5/9/97	<0.029	<0.029	<0.029	<0.029	2,200	650	10/31/95	0.2	19.5	NS	3/1/96	1.9	2.4	0.31	2.1	650
							1/17/96	0.5	10.0	NS	5/9/97	<0.15	<0.15	<0.15	<0.30	270
							2/28/96	3.9	NS	440						
							4/8/97	3.5	7.0	156						

<sup>a/</sup> Soil gas results determined by hand-held field instruments.

<sup>b/</sup> Summa canister results determined by Method TO-14.

<sup>c/</sup> Milligram per kilogram of soil (dry weight).

<sup>d/</sup> Total Petroleum Hydrocarbons (TPH) are diesel range organics determined by SW8015(mod.).

<sup>e/</sup> Total Recoverable Petroleum Hydrocarbons (TRPH) determined by SW418.1.

<sup>f/</sup> Total Volatile Hydrocarbons.

<sup>g/</sup> Parts per million, by volume.

<sup>h/</sup> Total Hydrocarbons determined by Method TO-14 using the total chromatographic peak area.

<sup>i/</sup> Not sampled.

Q:\PROJECTS\1611\000000\DP\TABLE1.XLS

Table 2

**Historical Soil Gas Readings <sup>a/</sup>  
From Monitoring Points MPA and MPB  
IRP Site ST-08  
Former Fuel Oil Storage Facility  
Pope AFB, North Carolina**

Date (mm/dd/yr)	Monitoring Point MPA-4.8 <sup>b/</sup>			Monitoring Point MPA-9.7		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv) <sup>c/</sup>	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	15.0	4.2	3,900	4.0	10.8	> 10,000
10/31/95	3.0	11.8	NS <sup>d/</sup>	2.3	15.5	NS
1/17/96	13.8	4.1	NS	18.3	2.0	NS
2/28/96	14.5	NS	230	20.0	NS	100
4/8/97	12.0	4.2	170	18.0	1.2	78

Date (mm/dd/yr)	Monitoring Point MPB-4.4			Monitoring Point MPB-9.2		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	15.1	4.6	> 10,000	1.2	15.0	> 10,000
10/31/95	3.1	13.2	NS	2.0	18.9	NS
1/17/96	NS	NS	NS	12.8	5.5	NS
2/28/96	NS <sup>d/</sup>	NS <sup>d/</sup>	NS <sup>d/</sup>	16.8	NS	160
4/8/97	NS <sup>d/</sup>	NS <sup>d/</sup>	NS <sup>d/</sup>	13.5	4.0	86

Table 2 (continued)

**Historical Soil Gas Readings**  
**From Monitoring Points MPC and MPD**  
**IRP Site ST-08**  
**Former Fuel Oil Storage Facility**  
**Pope AFB, North Carolina**

Date (mm/dd/yr)	Monitoring Point MPC-4.7			Monitoring Point MPC-9.7		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	0.0	12.0	> 10,000	NS	NS	NS
10/31/95	1.4	19.5	NS	0.7	21.0	NS
1/17/96	20.2	0.7	NS	20.5	0.6	NS
2/28/96	19.9	NS	84	20.8	NS	25
4/8/97	18.5	1.5	86	19.5	0.5	76

Date (mm/dd/yr)	Monitoring Point MPD-4.7			Monitoring Point MPD-8.7		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	18.7	2.5	> 10,000	10.5	9.9	> 10,000
10/31/95	2.8	12.7	NS	0.2	19.5	NS
1/17/96	16.5	3.0	NS	0.5	10.0	NS
2/28/96	NS <sup>d</sup>	NS <sup>d</sup>	NS <sup>d</sup>	3.9	NS	12
4/8/97	4.5	7.0	240	3.5	7.0	156

Table continued)

**Historical Soil Gas Readings  
From Vent Wells and Monitoring Wells  
IRP Site ST-08  
Former Fuel Oil Storage Facility  
Pope AFB, North Carolina**

Date (mm/dd/yr)	Vent Well VW-1 <sup>u</sup>			Vent Well VW-2 <sup>u</sup>		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	0.0	12.1	> 10,000	0.0	12.4	> 10,000
10/31/95	NS	NS	NS	NS	NS	NS
1/17/96	NS	NS	NS	NS	NS	NS
2/28/96	NS	NS	NS	NS	NS	NS
4/8/97	NS	NS	NS	NS	NS	NS

Date (mm/dd/yr)	Monitoring Well HF-1			Monitoring Well HF-2		
	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)	Oxygen (%)	Carbon Dioxide (%)	Total Volatile Hydrocarbons (ppmv)
3/13/95	0.4	11.0	> 10,000	0.0	8.1	19,800
10/31/95	NS	NS	NS	NS	NS	NS
1/17/96	19.2	1.3	NS	20.9	0.5	NS
2/28/96	20.0	NS	270	21.0	NS	66
4/8/97	18.0	1.25	190	19.8	0.3	1,400

- <sup>u</sup> All soil gas readings determined by hand-held instruments.
- <sup>w</sup> Depth for monitoring points are in feet below ground surface.
- <sup>x</sup> Parts per million, by volume.
- <sup>y</sup> Not sampled.
- <sup>z</sup> Not sampled because screen interval was submerged below perched water table.
- <sup>aa</sup> Vent wells VW-1 and VW-2 not sampled after system began operating on October 31, 1995.

Table 3a

Initial Pressure Response (inches of water)  
 Air Permeability Test #1  
 March 13, 1995  
 IRP Site ST-08  
 Pope AFB, North Carolina

Depth (feet bgs)	MPA		MPB		MPC	VW-2	MPD		MW-HF1
	4.8'	9.7'	4.4'	9.2'	4.7'	7.1' <sup>(a)</sup>	4.7'	8.7'	10.1' <sup>(a)</sup>
Elapsed Time (min: sec)									
00:30	0	0	-	0	0	0			
1:00	0	1.0	-	0	0	0	0.1	0	0.02
1:30	0	2.5	0.02	0	-	-	0.2	0	0.02
2:00	0	4.5	0.02	0	0	0	0.22	0	0.02
2:30	0	8.0	-	-	-	-	-	-	0.02
3:00	0	10.5	0.03	0	0	0	0.25	0	0.02
4:00	0.25	17.5	0.02	0	0	0	-	-	0.02
5:00	0.75	22.0	0.02	0	0	0	-	-	0.02
5:30	1.0	24.0	-	-	-	-	-	-	0.03
6:00	1.0	26.0	0.02	0.01	0	0.02	0.3	0	0.04
7:00	1.75	29.0	0.02	0.01	0	0.02	-	-	0.05
8:00	2.5	32.0	-	-	0	0.02	-	-	0.06
9:00	3.0	35.0	0.02	0.01	0	0.03	0.3	0	0.07
10:00	3.5	37.5	0.02	0.01	0	0.03	-	-	0.08
11:00	4.0	40.0	-	-	-	-	-	-	0.09
12:00	4.75	41.5	0.03	0.02	0	0.04	-	-	-
13:00	5.25	43.0	-	-	-	-	-	-	0.12
14:00	6.0	44.5	0.03	0.02	0.05	0.05	0.2	0	-
16:00	7.0	46.5	-	-	0.05	0.06	-	-	0.14
18:00	8.0	48.5	0.04	0.05	0.05	0.06	-	-	0.17
20:00	9.25	50.0	-	-	0.05	0.07	0.2	0	0.19
28:00	13.0	57.0	-	-	-	-	-	-	0.20
30:00	13.5	58.0	0.03	0.06	0.05	0.06	-	-	-
35:00	15.3	60.0	-	-	-	-	-	-	0.24
40:00	17.0	60.5	0.02	0.06	0.05	0.06	0.2	0	-
50:00	-	-	0.03	0.08	0.04	0.07	0.21	0	0.26
60:00	20.9	66.0	0.03	0.09	0.03	0.05	0.2	0	0.28
80:00	23.2	66.0	-0.07	0.04	0.03	0.05	0.09	0	0.29
90:00	24.0	67.0	-	-	0.03	0.05	-	-	0.27
100:00	-	-	-0.10	0.05	0.03	0.05	0.05	0	0.27

<sup>(a)</sup> Depth represents center of unsaturated portion of well screen.

Table 3b

Pressure Response (inches of water)  
 Air Permeability Test #2  
 March 13, 1995  
 IRP Site ST-08  
 Pope AFB, North Carolina

Depth (feet bgs)	MPB		MPC	MPD		MW-HF1
	4.4'	9.2'	4.7'	4.7'	8.7'	10.1' <sup>(a)</sup>
Elapsed Time (min: sec)						
00:30	0	0.10	4.0			
1:00	0.06	0.57	7.0	0	0	-
1:30	0.26	1.19	-	0	0	0.05
2:00	0.58	1.52	9.5	0	0	-
2:30	0.98	2.44	-	0	0	-
3:00	1.45	3.04	11.3	-	-	0.50
4:00	2.43	4.12	13.0	-	-	0.54
5:00	3.37	5.07	13.0	-	-	-
5:30	-	-	-	0.2	0.5	-
6:00	4.24	5.84	13.5	-	-	1.55
7:00	5.04	6.54	14.0	-	-	-
8:00	5.50	7.12	14.5	-	-	-
9:00	6.02	7.62	14.6	0.9	-	-
10:00	6.61	8.07	15.0	-	-	-
11:00	-	-	-	1.65	-	-
12:00	7.54	8.78	15.5	>2	1.2	2.28
13:00	-	-	-	>2	1.4	-
14:00	8.23	9.31	15.5	-	-	-
16:00	8.84	9.72	16.0	>2	1.9	2.53
18:00	9.31	10.05	16.2	3.5	2.5	-
20:00	9.66	10.30	16.5	4.25	2.9	-
22:00	9.95	10.49	16.5	5.0	3.3	2.75
24:00	-	-	-	-	-	-
30:00	10.72	10.96	16.75	-	-	2.80
35:00	11.01	11.12	17.0	6.5	5.0	2.85
40:00	11.17	11.20	17.0	7.0	5.6	2.90
45:00	10.91	11.27	-	7.1	6.1	2.90
50:00	10.76	11.30	17.1	7.75	6.5	-
55:00	10.59	11.32	-	8.0	6.8	2.95
60:00	10.63	11.34	17.3	8.0	7.0	-
130:00	11.27	12.42	17.7	8.3	7.3	3.0
				9.3	8.6	3.07

<sup>(a)</sup> Unsaturated screened interval was 7.5' - 12.7' below ground surface at MW-HF1.

Table 4

Respiration and Fuel Biodegradation Rates  
IRP Site ST-08  
Former Fuel Oil Storage Site  
Pope AFB, North Carolina

Location-Depth (ft bgs) <sup>b/</sup>	Initial (March 1995) <sup>a/</sup>			Interim (March 1996)			Interim (April 1997)		
	K <sub>o</sub> (% O <sub>2</sub> /min)	Biodegradation Rate (mg/kg/year) <sup>c/</sup>	Soil Temp. (°C)	K <sub>o</sub> (% O <sub>2</sub> /min)	Biodegradation Rate (mg/kg/year)	Soil Temp. (°C)	K <sub>o</sub> (% O <sub>2</sub> /min)	Biodegradation Rate (mg/kg/year)	Soil Temp. (°C)
MPA-4.8	0.0032	440	NS <sup>d/</sup>	0.0041	560	NS	0.0038	487	NS
MPA-9.7	0.0033	530	NS	0.0016	250	NS	0.0015	196	NS
MPB-4.4	0.0068	940	9.8	NS	NS	9.7	NS	NS	14.9
MPB-9.2	0.010	1400	11	0.00084	120	10.5	0.0013	172	14.1
MPC-4.7	0.012	1700	NS	0.00099	140	NS	0.0012	156	NS
MPC-9.7	NS	NS	NS	0.0012	170	NS	0.0011	142	NS
MPD-4.7	0.0069	940	NS	NS	NS	NS	0.0012	159	NS
MPD-8.7	0.012	1400	NS	0.00071	79	NS	0.0020	254	NS
VW-1	0.0034	460	NS	0.00076	100	NS	NS	NS	NS
VW-2	0.012	1700	NS	0.00069	94	NS	NS	NS	NS
HF-1	NS	NS	NS	NS	NS	NS	0.0014	186	NS
HF-2	NS	NS	NS	NS	NS	NS	0.00010	13	NS

<sup>a/</sup> Initial Respiration Test performed in March 1995, but system operation did not begin until October 31, 1995.

<sup>b/</sup> Feet below ground surface.

<sup>c/</sup> Milligrams of hydrocarbons per kilogram of soil per year.

<sup>d/</sup> Not sampled.

Table 5

**Historical Soil Gas Pressure Readings  
From Monitoring Points and Wells  
IRP Site ST-08  
Former Fuel Oil Storage Facility  
Pope AFB, North Carolina**

Date (mm/dd/yr)	Total System Flow (scfm) <sup>b/</sup>	System Pressure (in H <sub>2</sub> O) <sup>c/</sup>	Distance to Closest Vent Well (feet)									
			10	10	24.8	24.8	9.7	9.7	9.7	29.6	29.6	39.2
			Monitoring Locations and Depths <sup>a/</sup>									
			MPA-4.8 (in H <sub>2</sub> O)	MPA-9.7 (in H <sub>2</sub> O)	MPB-4.4 (in H <sub>2</sub> O)	MPB-9.2 (in H <sub>2</sub> O)	MPC-4.7 (in H <sub>2</sub> O)	MPC-9.7 (in H <sub>2</sub> O)	MPD-4.7 (in H <sub>2</sub> O)	MPD-8.7 (in H <sub>2</sub> O)	HF-1 (in H <sub>2</sub> O)	HF-2 (in H <sub>2</sub> O)
10/31/95	40	30.4	2.23	>20	3.48	11.87	17.4	>20	NS <sup>d/</sup>	6.58	NS	NS
1/17/96	48	38.8	2.18	15.68	15.33	14.08	17.89	20.2	14.28	10.04	3.9	2.33
2/28/96	49	49.8	5.3	19.5	0.76	13.9	18.51	19.5	17.7	10.21	4.4	2.23
4/8/97	39	72.0	3.97	16.32	7.41	8	11.82	12.41	4.49	5.04	1.89	0.68

<sup>a/</sup> Depths for monitoring points are in feet below ground surface.

<sup>b/</sup> Standard cubic feet per minute.

<sup>c/</sup> Inches of water (pressure).

<sup>d/</sup> Not sampled.



Table 6

**Historical Groundwater Levels and Free Product Measurements**  
**IRP Site ST-08**  
**Former Fuel Oil Storage Facility**  
**Pope AFB, North Carolina**

Date (mm/dd/yr)	HF-1			HF-2			VW-1			VW-2		
	Depth to Product	Depth to Water	Product Thickness	Depth to Product	Depth to Water	Product Thickness	Depth to Product	Depth to Water	Product Thickness	Depth to Product	Depth to Water	Product Thickness
	(ft btoc) <sup>a/</sup>	(ft btoc)	(ft)	(ft btoc)	(ft btoc)	(ft)	(ft btoc)	(ft btoc)	(ft)	(ft btoc)	(ft btoc)	(ft)
2/23/95	14.85	15.31	0.46	15.79	15.93	0.14	10.75	11.29	0.54	8.11	8.13	0.02
3/13/95	14.46	14.96	0.50	15.55	15.56	0.01	10.08	10.88	0.80	8.12	8.13	0.01
7/13/95	nm <sup>b/</sup>	nm	nm	nm	nm	nm	8.69	8.70	0.01	9.61	11.23	1.62
10/31/95	nm	nm	nm	nm	nm	nm	10.28	11.18	0.90	9.43	9.43	0.00
1/17/96	15.38	16.41	1.03	17.84	18.54	0.70	nm	nm	nm	nm	nm	nm
2/28/96	14.93	16.02	1.09	17.72	18.08	0.36	nm	nm	nm	nm	nm	nm
4/9/97	12.09	13.54	1.45	13.26	13.26	0.00	nm	nm	nm	nm	nm	nm

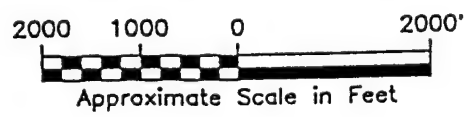
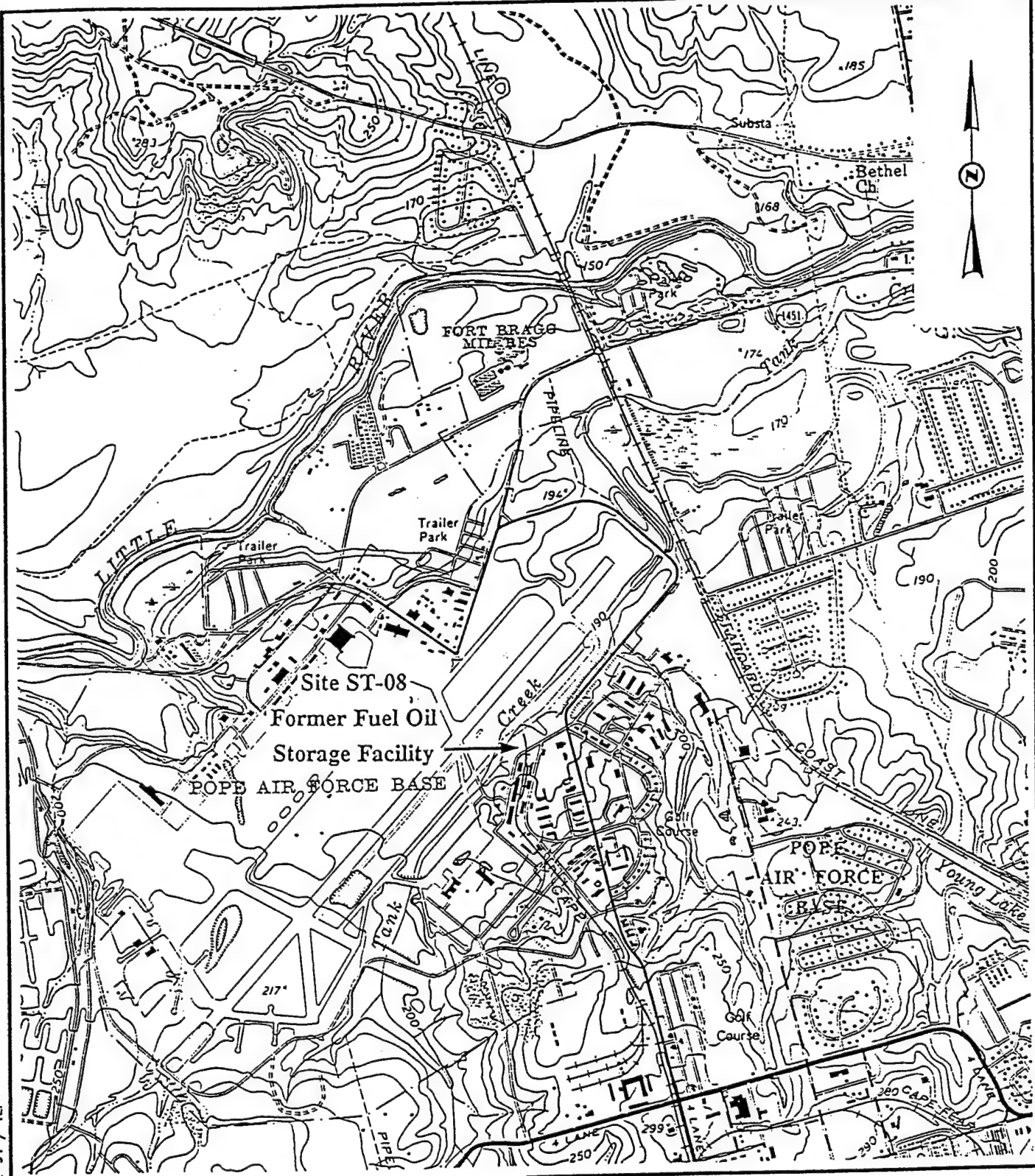
<sup>a/</sup> Feet below top of casing.

<sup>b/</sup> Not measured.

## FIGURES

- Figure 1 Topographic Map of Pope AFB
- Figure 2 Bioventing Pilot Test Location
- Figure 3 In-Situ Fuel Biodegradation Rates

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Pope Air Force Base Location Map

IRP Site ST-08  
Pope AFB  
Fayetteville, North Carolina

From: U.S.G.S. Overhills & Manchester, NC Quadrangles  
(7.5 Minute Topographic Map - 1971 & 1987)

• F13

UNDERGROUND  
BOX CULVERT  
(TANK CREEK)

F7 •

N

MW-HF2

F6 •

VW-2

F5 •

PO1-MPC

ELECTRICAL  
DISCONNECT

• F12

PO1-MPD

MW-HF1

PO1-MPB

F8 •

PO1-MPA

BLOWER  
SHED

90° PVC ELBOW  
W/ STICKUP

• F11

FORMER  
PIPING

F9

FORMER  
25,000-GALLON  
#2 FUEL OIL USTs (4)

2" PVC HEADER PIPE  
(BELOW GROUND)

• F10

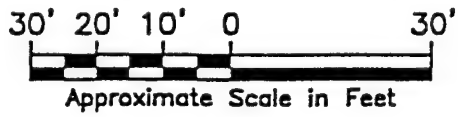
BOXCAR STREET

# LEGEND

- ⊗ Soil venting well.
- ▲ Soil vapor monitoring point.
- ⊕ Groundwater monitoring well.
- CPT/LIF screening point.
- ⊠ Piezometer (CPT-installed).
- Below grade PVC piping.
- ..... Below grade electrical line.

## Notes:

1. Locations of monitoring wells, CPT/LIF, Ws, and VMPs are estimated based on survey data provided by Pope AFB and field measurements.



Bioventing Pilot Test Location

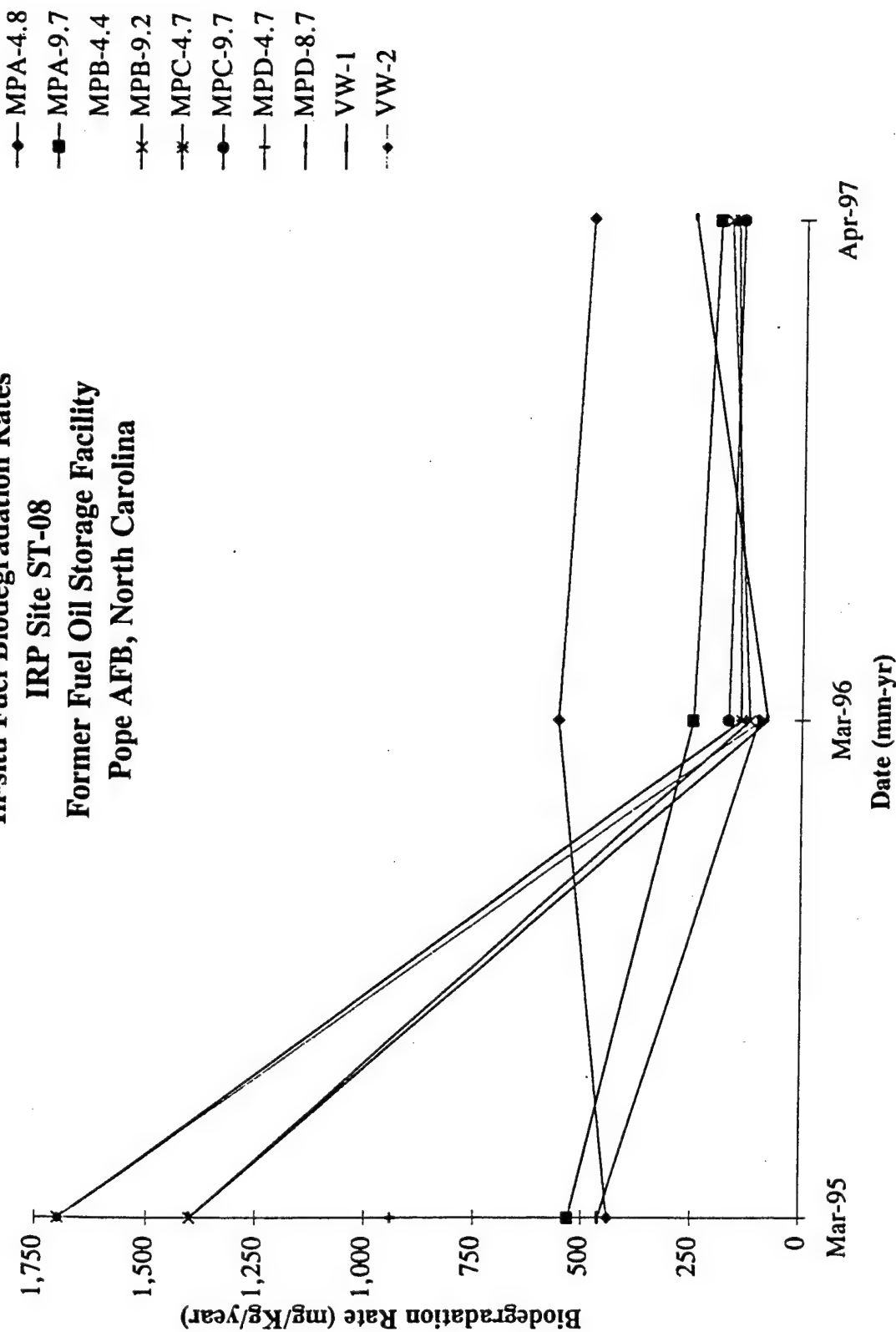
IRP Site ST-08  
Former Fuel Oil Storage Facility  
Pope AFB, North Carolina

PARSONS ENGINEERING SCIENCE, INC.

DWG / ps1-1 / 8-3-97 / MRP

Figure 3

**In-situ Fuel Biodegradation Rates  
IRP Site ST-08  
Former Fuel Oil Storage Facility  
Pope AFB, North Carolina**



**CSA  
PERFORMED BY  
URS GREINER 1996-1997**

## EXECUTIVE SUMMARY

URS Greiner, Inc. (URSG) has prepared this Comprehensive Site Assessment (CSA) for the United States Army Corps of Engineers, Omaha District under Contract Number DACW45-93-D-0015, Delivery Order Number 7. This CSA was completed for Site ST-08, Building 41105 at Pope Air Force Base, North Carolina. The purposes of this CSA are to summarize field investigation results, to report on the nature and extent of impacted soil and groundwater, and to make appropriate conclusions and recommendations.

Site ST-08, Building 41105 was formerly used as a fuel oil storage and distribution facility, housing four 25,000 gallon underground storage tanks. The site is located in the center of a grassy field between Taxiway B and Boxcar Street. Two previous studies were conducted. In May 1994, the U.S. Army Corps of Engineers (USACE) performed a soil gas survey. In August 1994, Parsons Engineering-Science (ES) conducted a soil gas/soil boring survey. Based on the results of the previous studies, a bioventing pilot study was undertaken at the site beginning in 1995 and is currently in progress.

The potential for human exposure to fuel oil contamination at the site is limited by minimal human activity and the limited exposure routes as the contamination is generally 8 feet below ground surface. Potential ecological receptors may include aquatic life in Tank Creek. Located immediately northwest of the site, Tank Creek flows into an underground culvert running in a northeasterly direction. The closest perpendicular distance between the culvert and the former UST basin is 100 feet. Tank Creek continues to flow in a northeasterly direction until it joins the Little River approximately 2.5 miles downstream.

There are currently no structures, other than the Tank Creek underground culvert, in the immediate vicinity of the site that could be impacted by the fuel oil free product or by VOC vapors migrating to the surface.

Activities performed during this project were used to evaluate subsurface soil and groundwater contamination. The following contaminants were found in concentrations exceeding applicable criteria.

- Total Petroleum Hydrocarbons (TPH) and oil and grease (O&G) in soil; and,
- benzene, ethylbenzene and naphthalene in groundwater.

It appears that the presently operating bioventing system can reduce soil contamination to remedial cleanup levels over time. However, the effectiveness of the technology will not be fully realized until free product is removed from the subsurface. Based primarily on cost, implementability and the estimated small quantity of free product to be removed (less than 3,000 gallons), URSG recommends completion of a groundwater natural attenuation study, implementing aggressive fluid vapor recovery, continued operation of the bioventing system and evaluation of its performance, and preparation of a Corrective Action Plan (CAP).

## **SITE ST-08 BUILDING 41105 (BOXCAR)**

Site ST-08, Building 41105 is the former fuel oil storage facility at Building 41105 is located in a grassy, open area near the center of the base between Taxiway B and Boxcar Street and adjacent to Tank Creek. The site was used as a #2 fuel oil storage and distribution center for the base. Fuel oil was delivered to the site by tanker trucks and rail cars, where it was unloaded and stored in 25,000 gallon USTs. The #2 fuel oil was then distributed throughout the base by delivery trucks and stored in smaller holding tanks, where the fuel oil was used for heating purposes.

There were four 25,000 gallon USTs, in operation from 1954 to 1985. In 1990, these USTs failed precision testing. In November 1992, the four tanks, ancillary piping, and fuel dispensers were excavated and removed. Presently there are no buildings or structures on the ground surface or subsurface in the vicinity of the former fuel storage facility. During excavation, soil contamination was encountered and free product was observed on water that collected in the open excavation. Contaminated soil was used to backfill the excavation on top of a plastic liner after the tanks were removed.

In May 1994, the US Army Corps of Engineers (USACE) performed a soil gas survey of the former UST site location due to the potential migration of fuel into the water table and Tank Creek. Analysis of the soil gas samples revealed the presence of benzene, toluene, ethylbenzene, xylenes (BTEX) and other volatile organic compounds (VOC). Detected concentrations were generally less than 10 parts per million by volume (ppmv). Low concentrations of BTEX and other VOC are typical for heavier fuels such as #2 fuel oil.

In August 1994, Parsons Engineering-Science, Inc. (Parsons ES) conducted a preliminary soil gas/soil boring survey at the former UST excavation area as part of a base-wide search for candidate bioventing study sites. Four temporary soil gas points and three shallow, hand-augered soil borings were installed within the former UST system excavation area. The points and borings were used to determine soil gas composition, identify fuel-contaminated soils, and provide lithologic characteristics. The soil gas composition was determined by monitoring total volatile hydrocarbon (TVH), oxygen (O<sub>2</sub>), and carbon dioxide (CO<sub>2</sub>) concentrations within the soil gas. TVH concentrations ranged from 980 ppmv to greater than 10,000 ppmv. Aerobic biodegradation was indicated by depleted O<sub>2</sub> and increased CO<sub>2</sub> levels in the soils. In addition, soil boring samples were collected and analyzed for Total Petroleum Hydrocarbons (TPH). TPH concentrations from soil boring samples ranged from 1,290 parts per million (ppm) to 4,160 ppm.

In February 1995, Parsons ES installed two air injection vent wells and four permanent vapor/pressure monitoring points. Soil samples were collected and tested for hydrocarbons. The results from the pilot study indicated that there was a reduction in soil and soil gas TPH and BTEX compounds. Additionally,



in March of 1995, two air permeability tests and an in situ respiration test were conducted.

Following evaluation of soils and soil gas data, permeability and respiration test results, Parsons ES installed a bioventing pilot test system, which began operating October 31, 1995. The goals of the pilot test were to:

- assess the potential to supply oxygen throughout contaminated soils;
- determine the rate of fuel degradation by microorganisms when stimulated by oxygen rich soil gas;
- evaluate sustenance of biodegradation rates to remedial endpoints; and,
- initiate bioremediation.

In April 1997, Parsons ES completed additional field activities associated with the Bioventing Pilot Study. An interim report is attached.

### CSA Field Activities

Field activities for the former fuel storage facility included a groundwater survey using direct push sampling (DPS), collection of subsurface soil samples, monitoring well installation and sampling, and well testing. Table 4-1 details the number of samples and corresponding analytical methods for the site.

DPS data was used as a field screening tool. Direct push groundwater samples were collected and analyzed in the field with a gas chromatograph. The data was then evaluated in order to determine the best locations for monitoring well placement. Soil and groundwater sampling data from DPS, newly installed wells, and well testing information were used for site characterization.

The following field activities were completed at ST-08, Building 41105:

- Two cone penetrometer points (CPT-02, CPT-03) were advanced in the field to assist in DPS and soil characterization.
- Fifteen direct push subsurface soil samples were collected for chemical analysis and soil characterization from five DPS points (DS-01 through DS-04, DS-08). Samples were taken at varying locations and depths to determine the horizontal and vertical extent of soil contamination.
- Eighteen direct push groundwater samples were collected from eighteen DPS points (DP-01 through DP-15, DP-24 through DP-26). Samples were taken at varying locations and depths to determine the horizontal and vertical extent of the groundwater contamination.
- Ten monitoring wells (one deep MW8-10 and nine shallow wells MW8-06 through MW8-09,

MW8-11 through MW8-15) were installed and developed. Well locations were based on results of the groundwater survey.

- One exploratory soil boring to bedrock (SB8-01) was performed to evaluate soil characterization.
- A soil sample was collected above and below the water table and analyzed for total organic carbon (TOC). One geotechnical sample was collected above the water table.
- A total of ten groundwater samples were collected from the ten new wells.
- Hydraulic conductivity tests were performed for the new wells.

Sampling point and well locations are provided in attached Figures along with the location of previously collected samples.

Attached are tables with information regarding samples collected, well construction information, hydraulic conductivity tests, and materials testing. Figures are also provided illustrating information about the site.

#### **Known and Potential Contamination Source Summary**

The known source of the subsurface #2 fuel oil contamination originated from the former fuel storage and distribution facility. The four 25,000 gallon USTs leaked fuel oil into the subsurface between the time USTs were installed in the early-to-mid 1970's and the time when the USTs were removed in 1992. The presence of free product floating on top of the groundwater table is a source of dissolved phase contamination in the groundwater and has created a contaminant "smear zone" within the vadose zone, however, the contamination itself remains in the vicinity of and immediately downgradient from the former UST area.

As part of the ongoing Comprehensive Site Assessment (CSA) URS Greiner is completing for the facility, concentrations of chlorinated hydrocarbons were identified in groundwater. The extent of chlorinated hydrocarbon groundwater contamination is currently unknown. Chlorinated hydrocarbons are not typically components of fuel oil contamination but rather of solvents. The focus of this CSA encompassed the known fuel oil contamination source from the former USTs.

Table 1. Site ST-08, Building 41105, Sampling Breakdown

Samples Parameter <sup>1</sup>	Matrix	Quality Control (A-E) Samples					Quality Assurance (MRD) Samples			
		Field Samples	Duplicates/Splits	Sampler Rinsates	Trip Blanks	Total QC Samples	QA Duplicates/Splits	QA Sampler Rinsates	QA Trip Blanks	Total QA Samples
VOA (601/602) (Field)	Ground Water Survey	18	1	2	0	21	0	0	0	0
VOC (8260A)+MTBE+Xylenes	Ground Water Samples	10	1	2	1	14	1	0	0	1
EDB (504)		9	1	1	1	12	1	0	0	1
Isopropyl ether (Mod. 602)		9	1	1	1	12	1	0	0	1
Dissolved Lead (3010/7421)		8	1	1	0	10	1	0	0	1
Semivolatiles +10 (625)		8	1	1	0	10	1	0	0	1
Water Quality <sup>2</sup> +Fe		1	0	1	0	2	1	0	0	1
L.B. Fuels (Mod. 8015/5030)	DPS Soil Samples	15	3	1	0	19	3	0	0	3
H.B. Fuels (Mod. 8015/3550)		15	3	1	0	19	3	0	0	3
O&G (9071)		15	3	1	0	19	3	0	0	3
TOC (9060)	Soil Boring Samples	1	0	0	0	1	0	0	0	0
Geotechnical (ASTMD)		1	0	0	0	1	0	0	0	0

Analytical methods, sample storage, and sample preservation requirements are outlined in Appendix A.

<sup>2</sup> If the well does not produce a sufficient volume of water, part or all of the water quality samples will be omitted. Water quality parameters are as follows: Total Alkalinity std. Meth, Hardness (SM2340B), Iron (6010), Nitrate plus Nitrite (353.2), Sulfate 9300), Total Dissolved Solids (160.1), Total Suspended Solid (160.2).

Table 2. Site ST-08, Building 41105, Summary of Hydrocone Test Results

Sample Location	Date	Sample Depth <sup>1</sup> (ft. bgs)	Lithology <sup>2</sup>	K <sup>3</sup> (ft/day)
DP8-01	9/30/96	33-34	SW (CPT8-02)	1.49
DP8-02	10/2/96	30-31	SW (CPT8-02)	1.98
DP8-03	9/27/96	30-31	SW (CPT8-02)	0.47
DP8-04	9/30/96	30-31	SW (MW8-10)	1.24
DP8-05	10/1/96	30-31	SW(MW8-10)	10.04
DP8-06	10/2/96	30-31	SW (MW8-10)	0.86
DP8-07	9/30/96	31-32	SW (MW8-10)	2.28
DP8-08	9/30/96	31-32	SW (MW8-10)	0.96
DP8-09	10/1/96	31-32	SW (MW8-10)	0.65
DP8-10	10/1/96	31-32	SW	0.88
DP8-11	10/2/96	31-32	SW (MW8-10)	0.88
DP8-12	9/27/96	31-32	SW	6.15
DP8-13	10/9/96	30-31	SW (CPT8-03)	0.89
DP8-14	10/1/96	30-31	SW (CPT8-03)	0.4
DP8-15	10/1/96	42-43	SW (CPT8-03)	0.12
DP8-24	10/9/96	30-31	SW	1.11
DP8-25	10/9/96	30-31	SW (CPT8-03)	0.42
DP8-26	10/10/96	30-31	SW	1.69

bgs - Below ground surface  
K - Hydraulic Conductivity

Note: 1- Corresponds to the 1-foot Hydrocone sampler screen interval. Depth to groundwater at the site during sampling was estimated to range from 24 to 25-feet bgs due primarily to an upper confining unit starting at that level.  
2 - Unified Soil Classification System description of logged soils at same level bgs from nearest CPT point or monitoring well boring as indicated in parentheses. Where distance too large (>100 ft.), lithology is estimated and no correlation location is provided.  
3 - Direct Push Hydrocone calculations based on Bouwer and Rice, 1976.

**Table 3. Site ST-08, Building 41105, Well Construction Information**

WELL	DATE INSTALLED	ELEVATION OF CASING <sup>1</sup>	TOTAL DEPTH <sup>1</sup> (referenced to top of casing)	SCREENED INTERVAL <sup>1</sup> (bgs from TOC)	BENTONITE SEAL <sup>1</sup> (bgs from TOC)	GROUT INTERVAL <sup>1</sup> (bgs from TOC)
MW8-06	01/14/97	195.74	23	13-23	9-11	0-9
MW8-07	01/15/97	195.53	19	9-19	5-7	0-5
MW8-08	01/15/97	196.42	18	8-18	4-6	0-4
MW8-09	01/15/97	195.98	20	10-20	6-8	0-6
MW8-10	01/16/97	193.24	38	35-38	31-33	0-31
MW8-11	01/17/97	194.88	23	13-23	9-11	0-9
MW8-12	01/21/97	191.71	21	11-21	7-9	0-7
MW8-13	01/21/97	191.14	22	12-22	8-10	0-8
MW8-14	01/21/97	192.17	20	10-20	6-8	0-6
MW8-15	01/21/97	191.59	20	10-20	6-8	0-6
MWHF1	existing well	missing	17.20			
MWHF2	existing well	194.96	17.42			

bgs - below ground surface

Note 1: All measurements in feet.

Table 4. Site ST-08, Building 41105, Aquifer Test Results

Well	Test No.	Date Tested	K (feet per day)	Soil Type
MW8-06	1	04/04/97	0.61	fine sand to silty clay
MW8-07	1	04/04/97	4.56	fine-med sand w/ trace silt
MW8-08	1	04/03/97	1.19	fine sand to silty clay
MW8-09	1	04/03/97	1.62	fine-med sand to silty clay
MW8-10	1	04/04/97	15.19	coarse sand
MW8-11	1	04/04/97	0.58	fine silty sand to silty clay
MW8-12	1	04/04/97	2.94	fine-med silty sand interbedded with silty clay
MW8-13	1	04/04/97	2.32	fine silty sand to silty clay
MW8-15	1	04/15/97	0.91	fine-med sand to silty clay

K - hydraulic conductivity

**Table 4-5. Site ST-08, Building 41105, Geotechnical Information**

Sample I.D.	Well Location	Soil Classification	% Moisture	% Fines	Specific Gravity	Grain Size Predicted $K_{av}$
ST-08-SB-F-02-08	MW8-08	SP-SC	9.9	10.3	2.62	13.2 ft •d <sup>-1</sup>
ST-08-SB-F-02-14	MW8-08	SC	20.7	13.3	2.63	12.6 ft •d <sup>-1</sup>
ST-08-SB-F-03-08	MW8-12	SC	17.6	14.4	2.65	0.03 ft •d <sup>-1</sup>
ST-08-SB-F-03-18	MW8-12	SP	24.6	3.9	2.66	187 ft •d <sup>-1</sup>

**Notes:**

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

$K_{av}$  = Average Hydraulic Conductivity Value

**SUMMARY OF ANALYTICAL RESULTS**  
**Site ST-08, 41105**  
**Monitoring Well Groundwater**

Location I.D.			MW8-06	MW8-07	MW8-08	MW8-09	MW8-10
Sample I.D.			ST08MWF1300	ST08MWF1100	ST08MWF1200	ST08MWF1400	ST08MWF0900
Depth Interval (ft.)			0-0	0-0	0-0	0-0	0-0
Date Sampled			02/05/97	02/04/97	02/05/97	02/05/97	02/04/97
Parameter	Criteria *	Units					
<b>Volatile Organic</b>							
ACETONE	700(a)	UG/L			14		
TRICHLOROETHYLENE (TCE)	2.8(a)	UG/L			1		
BENZENE	1(a)	UG/L			5		
TOLUENE	1000(a)	UG/L		1			0.5
ETHYLBENZENE	29(a)	UG/L			14		2
TOTAL XYLENES	530(a)	UG/L			8		10
ISOPROPYL ETHER	70(c)	UG/L	NA				
<b>Semivolatile Organic</b>							
TOTAL BTEX		UG/L		1	27		12.5
TOTAL VOLATILE		UG/L		1	42		12.5
<b>Semivolatile Organic</b>							
NAPHTHALENE	21(a)	UG/L	NA		30		
ACENAPHTHENE	80(d)	UG/L	NA		3		
DIETHYL PHTHALATE	5000(a)	UG/L	NA				
FLUORENE	280(a)	UG/L	NA		5		
PHENANTHRENE	210(a)	UG/L	NA		3		
bis(2-ETHYLHEXYL) PHTHALATE	10(b)	UG/L	NA		2		
<b>Metals</b>							
IRON	300(a)	UG/L	NA	NA	NA	NA	NA
<b>Metals (Dissolved)</b>							
LEAD	15(a)	UG/L	NA				
<b>Non-metallic Inorganic Species</b>							
SULFATE (AS SO4)	250(f)	MG/L	NA	NA	NA	NA	NA
<b>Miscellaneous Assays</b>							
ALKALINITY, TOTAL (AS CaCO3)	2(f)	MG/L	NA	NA	NA	NA	NA
HARDNESS (AS CaCO3), NONCARBONATE	1(f)	MG/L	NA	NA	NA	NA	NA
TOTAL ORGANIC CARBON	0.5(f)	MG/L	NA	NA	NA	NA	NA
SUSPENDED SOLIDS (RESIDUE,	5(f)	MG/L	NA	NA	NA	NA	NA
TOTAL DISSOLVED SOLIDS (RESIDUE,	500(a)	MG/L	NA	NA	NA	NA	NA

Only detected results reported.

NA - Not Analyzed.

\* North Carolina Criteria for Groundwater.

(a) - Numeric Class GA Groundwater Standard listed in North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section 0202(g), dated November 8, 1993.

(b) - The applicable criteria for this analyte has been established at the PQL based on the criteria stipulated in NCAC, Title 15A, Subchapter 2L, Section 0202(b)1, dated November 8, 1997.

(c) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 17, 1994.

(d) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated May 16, 1995.

(e) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 7, 1995.

(f) - This analyte represents a general water chemistry parameter. As such, nonspecific criteria, i.e. ARAR, has been interpreted.

○ - Result exceeds appropriate criteria

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**SUMMARY OF ANALYTICAL RESULTS**  
**Site ST-08, 41105**  
**Monitoring Well Groundwater**

Location I.D.			MW8-11	MW8-11	MW8-11	MW8-12	MW8-13
Sample I.D.			ST08MWD1500	ST08MWF1500	ST08MWF1500	ST08MWF0700	ST08MWD0600
Depth Interval (ft.)			0-0	0-0	0-0	0-0	0-0
Date Sampled			05/13/97	02/05/97	05/13/97	02/03/97	02/04/97
Parameter	Criteria *	Units	FR1				FR1
<b>Volatile Organic</b>							
ACETONE	700(a)	UG/L	NA	25	NA		
TRICHLOROETHYLENE (TCE)	2.8(a)	UG/L	NA		NA		2
BENZENE	1(a)	UG/L	NA	54	NA		
TOLUENE	1000(a)	UG/L	NA	3	NA		
ETHYLBENZENE	29(a)	UG/L	NA	36	NA		
TOTAL XYLENES	530(a)	UG/L	NA	180	NA		
ISOPROPYL ETHER	70(e)	UG/L	NA	2.4	NA	NA	
TOTAL BTEX		UG/L	NA	273	NA		
TOTAL VOLATILE		UG/L	NA	300.4	NA		2
<b>Semivolatile Organic</b>							
NAPHTHALENE	21(a)	UG/L	NA	4	NA	NA	
ACENAPHTHENE	80(d)	UG/L	NA	1	NA	NA	
DIETHYL PHTHALATE	5000(a)	UG/L	NA		NA	NA	
FLUORENE	280(a)	UG/L	NA	0.8	NA	NA	
PHENANTHRENE	210(a)	UG/L	NA		NA	NA	
bis(2-ETHYLHEXYL) PHTHALATE	10(b)	UG/L	NA		NA	NA	
<b>Metals</b>							
IRON	300(a)	UG/L	NA	1650	NA	NA	NA
<b>Metals (Dissolved)</b>							
LEAD	15(a)	UG/L	NA	2.4	NA	NA	3.8
<b>Non-metallic Inorganic Species</b>							
SULFATE (AS SO <sub>4</sub> )	250(f)	MG/L	12.1	42	11.9	NA	NA
<b>Miscellaneous Assays</b>							
ALKALINITY, TOTAL (AS CaCO <sub>3</sub> )	2(f)	MG/L	NA	14.4	NA	NA	NA
HARDNESS (AS CaCO <sub>3</sub> ), NONCARBONATE	1(f)	MG/L	NA	5.5	NA	NA	NA
TOTAL ORGANIC CARBON	0.5(f)	MG/L	NA	NA	NA	4.9	NA
SUSPENDED SOLIDS (RESIDUE,	5(f)	MG/L	NA	1160	NA	NA	NA
TOTAL DISSOLVED SOLIDS (RESIDUE,	500(a)	MG/L	NA	111	NA	NA	NA

Only detected results reported.

NA - Not Analyzed.

\* North Carolina Criteria for Groundwater.

(a) - Numeric Class GA Groundwater Standard listed in North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section 0202(g), dated November 8, 1993.

(b) - The applicable criteria for this analyte has been established at the PQL based on the criteria stipulated in NCAC, Title 15A, Subchapter 2L, Section 0202(b)1, dated November 8, 1997.

(c) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 17, 1994.

(d) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated May 16, 1995.

(e) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 7, 1995.

(f) - This analyte represents a general water chemistry parameter. As such, nonspecific criteria, i.e. ARAR, has been interpreted.

○ - Result exceeds appropriate criteria

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# SUMMARY OF ANALYTICAL RESULTS

Site ST-08, 41105

Monitoring Well Groundwater

Location I.D.			MW8-13	MW8-14	MW8-15
Sample I.D.			ST08MWF0600	ST08MWF1000	ST08MWF0800
Depth Interval (ft.)			0-0	0-0	0-0
Date Sampled			02/04/97	02/04/97	02/04/97
Parameter	Criteria *	Units			
<b>Volatile Organic</b>					
ACETONE	700(a)	UG/L			28
TRICHLOROETHYLENE (TCE)	2.8(a)	UG/L	0.8		
BENZENE	1(a)	UG/L			
TOLUENE	1000(a)	UG/L			
ETHYLBENZENE	29(a)	UG/L			1
TOTAL XYLENES	530(a)	UG/L			3
ISOPROPYL ETHER	70(e)	UG/L			
TOTAL BTEX		UG/L			4
TOTAL VOLATILE		UG/L	0.8		32
<b>Semivolatile Organic</b>					
NAPHTHALENE	21(a)	UG/L			
ACENAPHTHENE	80(d)	UG/L			
DIETHYL PHTHALATE	5000(a)	UG/L		2	
FLUORENE	280(a)	UG/L			
PHENANTHRENE	210(a)	UG/L			
bis(2-ETHYLHEXYL) PHTHALATE	10(b)	UG/L			
<b>Metals</b>					
IRON	300(a)	UG/L	NA	NA	NA
<b>Metals (Dissolved)</b>					
LEAD	15(a)	UG/L	4.9	14.2	8.6
<b>Non-metallic Inorganic Species</b>					
SULFATE (AS SO4)	250(f)	MG/L	NA	NA	NA
<b>Miscellaneous Assays</b>					
ALKALINITY, TOTAL (AS CaCO3)	2(f)	MG/L	NA	NA	NA
HARDNESS (AS CaCO3), NONCARBONATE	1(f)	MG/L	NA	NA	NA
TOTAL ORGANIC CARBON	0.5(f)	MG/L	NA	NA	NA
SUSPENDED SOLIDS (RESIDUE,	5(f)	MG/L	NA	NA	NA
TOTAL DISSOLVED SOLIDS (RESIDUE,	500(a)	MG/L	NA	NA	NA

Only detected results reported.

NA - Not Analyzed.

\* North Carolina Criteria for Groundwater.

(a) - Numeric Class GA Groundwater Standard listed in North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0202(g), dated November 8, 1993.

(b) - The applicable criteria for this analyte has been established at the PQL based on the criteria stipulated in NCAC, Title 15A, Subchapter 2L, Section .0202(b)1, dated November 8, 1997.

(c) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 17, 1994.

(d) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated May 16, 1995.

(e) - The applicable criteria for this analyte is based on the interim maximum allowable concentration established by NC DEHNR Public Notice dated August 7, 1995.

(f) - This analyte represents a general water chemistry parameter. As such, nonspecific criteria, i.e. ARAR, has been interpreted.

○ - Result exceeds appropriate criteria

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## SUMMARY OF ANALYTICAL RESULTS

Site ST-08, 41105

Soils

Location I.D.			DS8-01	DS8-01	DS8-01	DS8-02	DS8-02
Sample I.D.			ST08DSF0110	ST08DSF0115	ST08DSF0120	ST08DSF0210	ST08DSF0215
Depth Interval (ft.)			10-12	15-17	20-22	10-12	15-17
Date Sampled			10/07/96	10/07/96	10/11/96	10/11/96	10/11/96
Parameter	Criteria *	Units					
<b>Volatile Organic</b>							
METHYLENE CHLORIDE	85000	UG/KG	NA	NA	NA	NA	NA
1,1-DICHLOROETHANE	780000(a)	UG/KG	NA	NA	NA	NA	NA
TOLUENE	1600000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DIBROMO-3-CHLOROPROPANE	460	UG/KG	NA	NA	NA	NA	NA
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	390000(a)	UG/KG	NA	NA	NA	NA	NA
n-BUTYLBENZENE	78000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DICHLOROBENZENE	700000(a)	UG/KG	NA	NA	NA	NA	NA
NAPHTHALENE	310000(a)	UG/KG	NA	NA	NA	NA	NA
TOTAL BTEX		UG/KG	NA	NA	NA	NA	NA
TOTAL VOLATILE		UG/KG	NA	NA	NA	NA	NA
<b>Petroleum Hydrocarbon Mixtures</b>							
GASOLINE COMPONENTS		MG/KG					13.2
DIESEL COMPONENTS		UG/KG				25000	47000
OIL & GREASE, TOTAL REC		UG/KG	59.4	350			14.2
TOTAL PETROLEUM		MG/KG	0.059	0.35		25	60.214
<b>Metals</b>							
BARIUM	550(a)	MG/KG	NA	NA	NA	NA	NA
CHROMIUM, TOTAL	39(a)(b)	MG/KG	NA	NA	NA	NA	NA
LEAD	400(c)	MG/KG	NA	NA	NA	NA	NA
<b>Miscellaneous Assays</b>							
TOTAL ORGANIC CARBON		MG/KG	NA	NA	NA	NA	NA

Only detected results reported.

NA - Not Analyzed.

\* EPA Region III Residential Soil Ingestion Risk - Based Concentrations.

(b) - Risk-based concentrations for chromium are based on levels for chromium VI and compounds

(c) - Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment, October 1996.

(d) - Risk-based concentrations for cis-1,3-dichloropropene and trans-1,3-dichloropropene are based on Total 1,3-dichloropropene.

(e) - Risk-based concentrations for alpha-chlordane and gamma-chlordane are based on chlordane.

 - Result exceeds appropriate criteria

**SUMMARY OF ANALYTICAL RESULTS**  
**Site ST-08, 41105**  
**Soils**

Location I.D.			DS8-02	DS8-03	DS8-03	DS8-03	DS8-04
Sample I.D.			ST08DSF0220	ST08DSF0310	ST08DSF0315	ST08DSF0320	ST08DSD0405
Depth Interval (ft.)			20-22	10-12	15-17	20-22	5-7
Date Sampled			10/11/96	10/14/96	10/14/96	10/14/96	10/17/96
Parameter	Criteria *	Units					FR1
<b>Volatile Organic</b>							
METHYLENE CHLORIDE	85000	UG/KG	NA	NA	NA	NA	NA
1,1-DICHLOROETHANE	780000(a)	UG/KG	NA	NA	NA	NA	NA
TOLUENE	1600000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DIBROMO-3-CHLOROPROPANE	460	UG/KG	NA	NA	NA	NA	NA
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	390000(a)	UG/KG	NA	NA	NA	NA	NA
n-BUTYLBENZENE	78000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DICHLOROBENZENE	700000(a)	UG/KG	NA	NA	NA	NA	NA
NAPHTHALENE	310000(a)	UG/KG	NA	NA	NA	NA	NA
TOTAL BTEX		UG/KG	NA	NA	NA	NA	NA
TOTAL VOLATILE		UG/KG	NA	NA	NA	NA	NA
<b>Petroleum Hydrocarbon Mixtures</b>							
GASOLINE COMPONENTS		MG/KG	2.6	90.5	1620	21.8	
DIESEL COMPONENTS		UG/KG		1600000	500000	130000	
OIL & GREASE, TOTAL REC		UG/KG		1470	98.8	118	428
TOTAL PETROLEUM		MG/KG	2.6	1691.97	2120.099	151.918	0.428
<b>Metals</b>							
BARIUM	550(a)	MG/KG	NA	NA	NA	NA	NA
CHROMIUM, TOTAL	39(a)(b)	MG/KG	NA	NA	NA	NA	NA
LEAD	400(c)	MG/KG	NA	NA	NA	NA	NA
<b>Miscellaneous Assays</b>							
TOTAL ORGANIC CARBON		MG/KG	NA	NA	NA	NA	NA

Only detected results reported.  
 NA - Not Analyzed.

\* EPA Region III Residential Soil Ingestion Risk - Based Concentrations.

(b) - Risk-based concentrations for chromium are based on levels for chromium VI and compounds

(c) - Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment, October 1996.

(d) - Risk-based concentrations for cis-1,3-dichloropropene and trans-1,3-dichloropropene are based on Total 1,3-dichloropropene.

(e) - Risk-based concentrations for alpha-chlordane and gamma-chlordane are based on chlordane.

○ - Result exceeds appropriate criteria

02/04/98

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## SUMMARY OF ANALYTICAL RESULTS

Site ST-08, 41105

Soils

Location I.D.			DS8-04	DS8-04	DS8-04	DS8-04	DS8-04
Sample I.D.			ST08DSD0410	ST08DSD0415	ST08DSF0405	ST08DSF0410	ST08DSF0415
Depth Interval (ft.)			10-12	15-17	5-7	10-12	15-17
Date Sampled			10/14/96	10/14/96	10/17/96	10/14/96	10/14/96
Parameter	Criteria *	Units	FRI	FRI			
<b>Volatile Organic</b>							
METHYLENE CHLORIDE	85000	UG/KG	NA	NA	NA	NA	NA
1,1-DICHLOROETHANE	780000(a)	UG/KG	NA	NA	NA	NA	NA
TOLUENE	1600000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DIBROMO-3-CHLOROPROPANE	460	UG/KG	NA	NA	NA	NA	NA
1,3,5-TRIMETHYLBENZENE (MESITYLENE)	390000(a)	UG/KG	NA	NA	NA	NA	NA
n-BUTYLBENZENE	78000(a)	UG/KG	NA	NA	NA	NA	NA
1,2-DICHLOROBENZENE	700000(a)	UG/KG	NA	NA	NA	NA	NA
NAPHTHALENE	310000(a)	UG/KG	NA	NA	NA	NA	NA
TOTAL BTEX		UG/KG	NA	NA	NA	NA	NA
TOTAL VOLATILE		UG/KG	NA	NA	NA	NA	NA
<b>Petroleum Hydrocarbon Mixtures</b>							
GASOLINE COMPONENTS		MG/KG					
DIESEL COMPONENTS		UG/KG					
OIL & GREASE, TOTAL REC		UG/KG	80.2	77.7	534	104	46.9
TOTAL PETROLEUM		MG/KG	0.08	0.078	0.534	0.104	0.047
<b>Metals</b>							
BARIUM	550(a)	MG/KG	NA	NA	NA	NA	NA
CHROMIUM, TOTAL	39(a)(b)	MG/KG	NA	NA	NA	NA	NA
LEAD	400(c)	MG/KG	NA	NA	NA	NA	NA
<b>Miscellaneous Assays</b>							
TOTAL ORGANIC CARBON		MG/KG	NA	NA	NA	NA	NA

Only detected results reported.

NA - Not Analyzed.

\* EPA Region III Residential Soil Ingestion Risk - Based Concentrations.

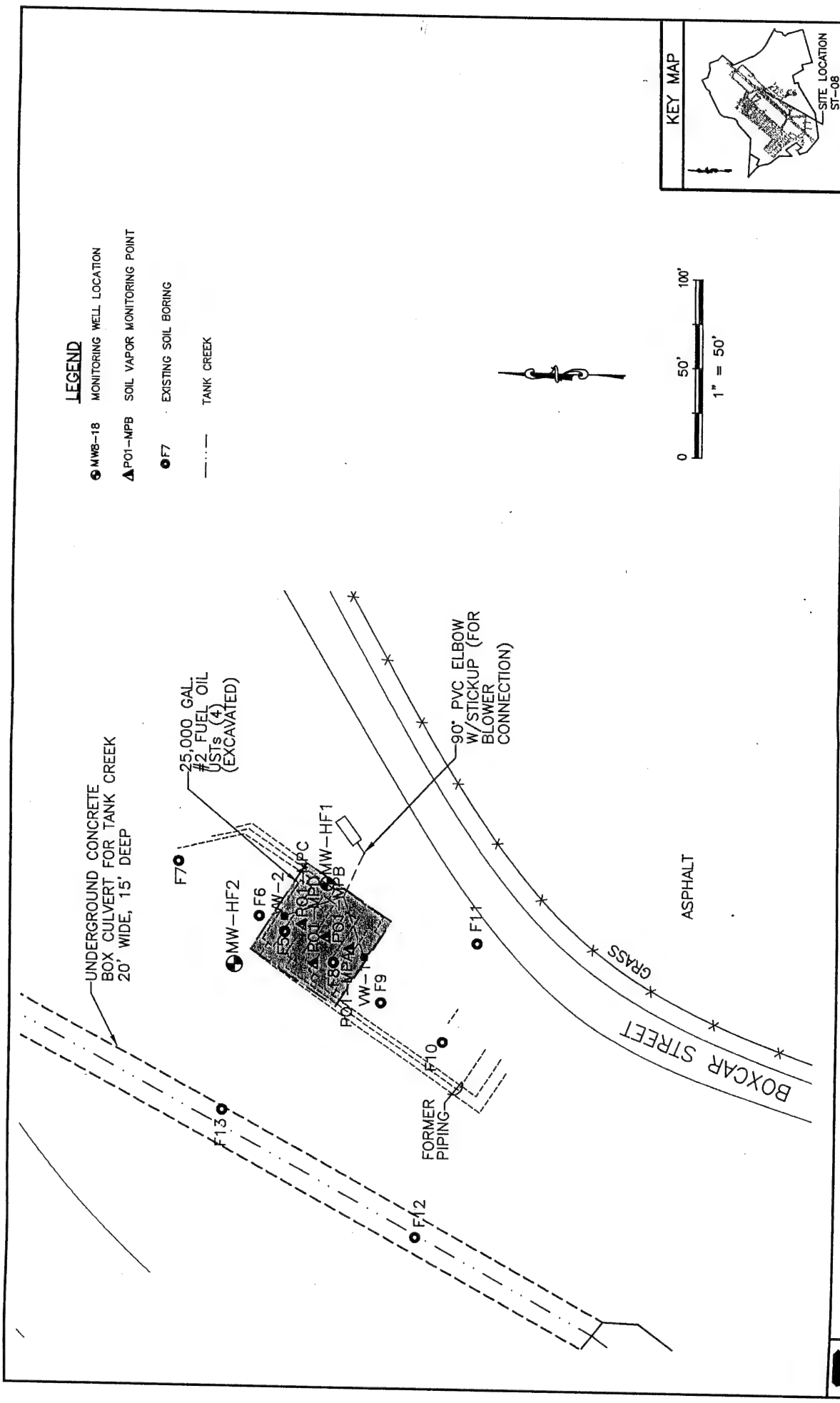
(b) - Risk-based concentrations for chromium are based on levels for chromium VI and compounds

(c) - Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment, October 1996.

(d) - Risk-based concentrations for cis-1,3-dichloropropene and trans-1,3-dichloropropene are based on Total 1,3-dichloropropene.

(e) - Risk-based concentrations for alpha-chlordane and gamma-chlordane are based on chlordane.

 - Result exceeds appropriate criteria



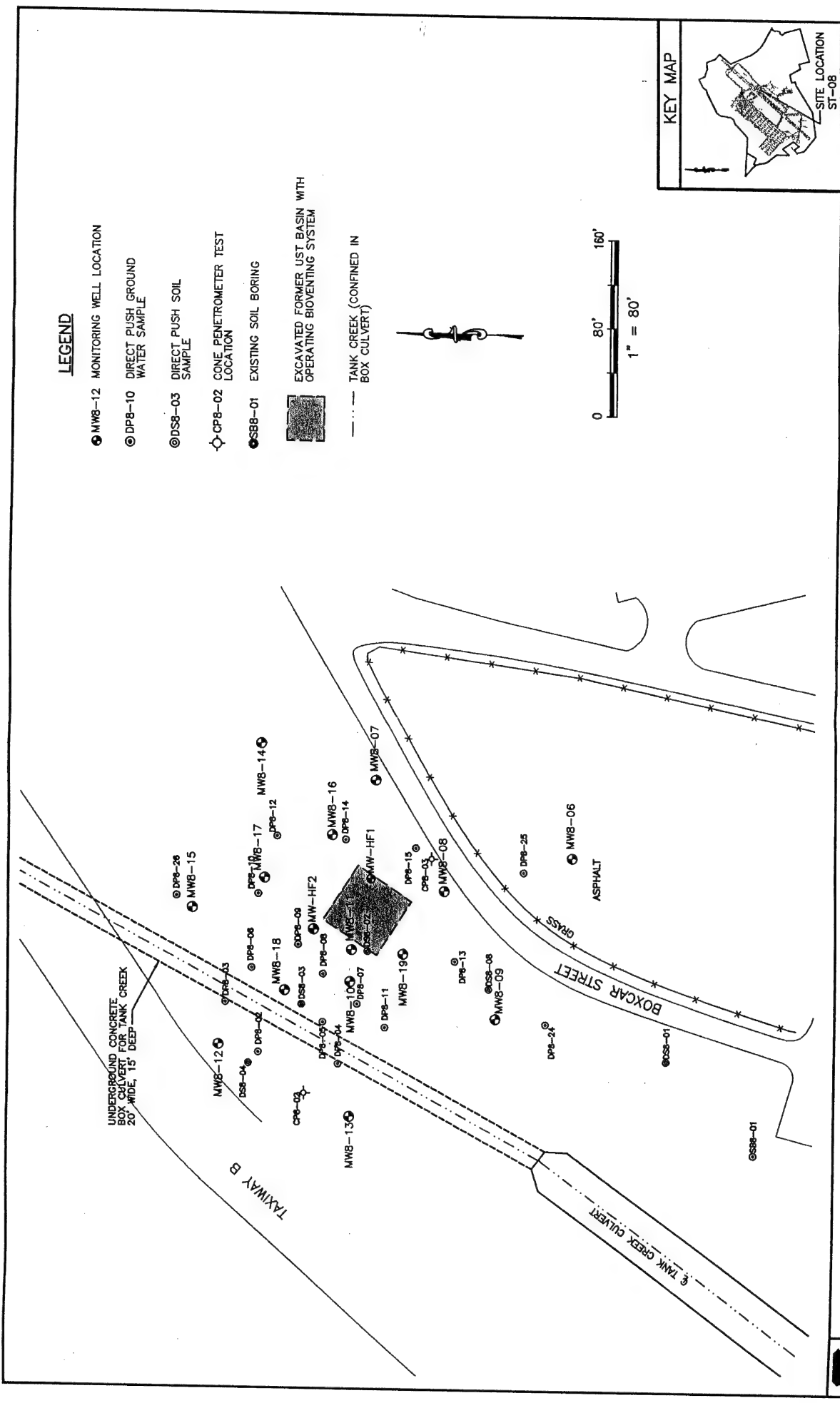
**LEGEND**

- MWB-18 MONITORING WELL LOCATION
- ▲ PO1-MPB SOIL VAPOR MONITORING POINT
- F7 EXISTING SOIL BORING
- TANK CREEK

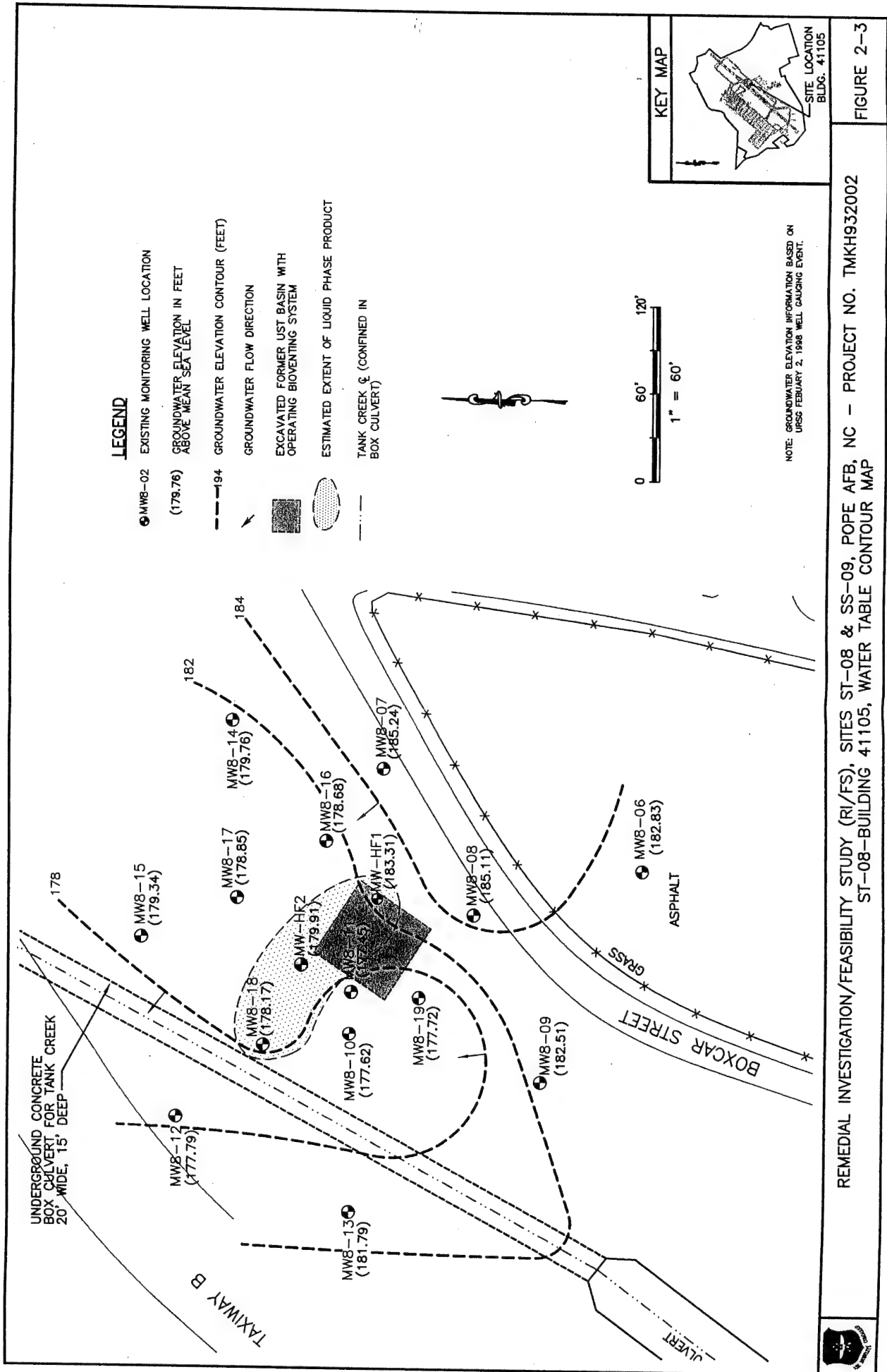


REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), SITES ST-08 & SS-09, POPE AFB, NC - PROJECT NO. TMKH932002  
ST-08, BUILDING 41105, SITE MAP

FIGURE 2-1



REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), SITES ST-08 & SS-09, POPE AFB, NC - PROJECT NO. TMKH932002  
ST-08, CSA SAMPLE LOCATIONS MAP

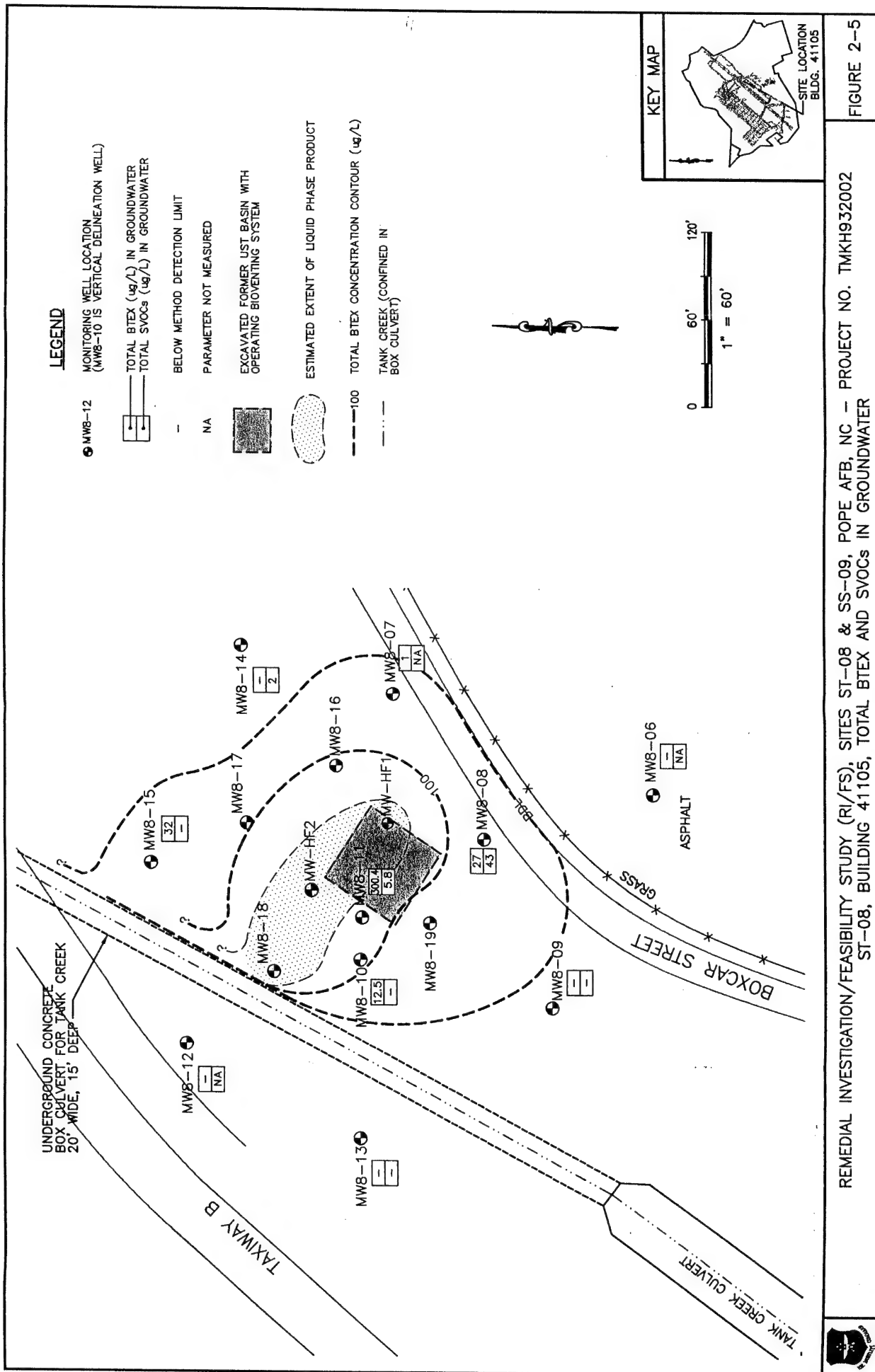


REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), SITES ST-08 & SS-09, POPE AFB, NC - PROJECT NO. TMKH932002  
ST-08-BUILDING 41105, WATER TABLE CONTOUR MAP





REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), SITES ST-08 & SS-09, POPE AFB, NC - PROJECT NO. TMKH932002  
ST-08, BUILDING 41105, TOTAL OIL AND GREASE AND TPH IN SOIL



REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS), SITES ST-08 & SS-09, POPE AFB, NC — PROJECT NO. TMKH932002  
ST-08, BUILDING 41105, TOTAL BTEX AND SVOCs IN GROUNDWATER

**APPENDIX C**  
**FIELD DATA FORMS**

# GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: 9/POSBL CONTRACTOR: Parsons 13 DATE SPUD: 12/14/98  
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: \_\_\_\_\_  
 JOB NO.: 73854.04020 DRLG METHOD: 1.1 ELEVATION: 180 + msl  
 LOCATION: \_\_\_\_\_ BORING DIA.: 2" TEMP: 60° - 70°  
 GEOLOGIST: T. DRAKE DRLG FLUID: \_\_\_\_\_ WEATHER: Sunny  
 COMMENTS: \_\_\_\_\_

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			Gravel								
				Sand & gravel								
	5			Silty Sands								
				Li Brown								
	10			Silty Sands	9.5		Lier					
				Li Brown								
	15											
	20											
	25											
	30											
	35											

## NOTES

bgs - Below Ground Surface  
 GS - Ground Surface  
 TOC - Top of Casing  
 NS - Not Sampled  
 SAA - Same As Above  
 U - Undetected

## SAMPLE TYPE

D - DRIVE  
 C - CORE  
 G - GRAB



Water level drilled

## GEOLOGIC BORING LOG

Risk-Based Approach to Remediation

**PARSONS  
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

# GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: 98BOSB2 CONTRACTOR: Parsons ES DATE SPUD: 12/10/98  
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: 12/10/98  
 JOB NO.: 7318540400 DRLG METHOD: Geoprobe ELEVATION: 180 + MSL  
 LOCATION: T. DRAC-20 BORING DIA.: 2" TEMP: 60-70°  
 GEOLOGIST: T. DRAC-20 DRLG FLUID: Water WEATHER: Sunny  
 COMMENTS: Start 0830

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample		Penet Res	PID(ppm)	TLV(ppm)	BTX(ppm)	TPH (ppm)
					No.	Depth (ft)					
	1			Sand & Gravel (backfill) in extension reddish brown, no odor							
				Sandy Clay, Light gray no odor							
	5			Sandy Clay w/ little sand white to gray, no odor							
				Sand white no odor							
	10			Clay very soft Greasy no odor							
				Sand white medium color	1	12'					
	15			Sand/Silt D fine - very wet light color							
				Sand Gravel Yellowish color strong color							
	20										
	25										
	30										
	35										

## NOTES

bgs - Below Ground Surface  
 GS - Ground Surface  
 TOC - Top of Casing  
 NS - Not Sampled  
 SAA - Same As Above  
 U - Undetected

## SAMPLE TYPE

D - DRIVE  
 C - CORE  
 G - GRAB

▼ Water level drilled

## GEOLOGIC BORING LOG

Risk-Based Approach to Remediation

**PARSONS  
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

# GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: CRPOS133 CONTRACTOR: Parsons ES DATE SPUD: 12/11/97  
 CLIENT: AFLC RIG TYPE: Geoprobe DATE CMPL: \_\_\_\_\_  
 JOB NO.: 731854.0440 DRLG METHOD: " ELEVATION: 180+ msl  
 LOCATION: \_\_\_\_\_ BORING DIA.: 2" TEMP: 60° - 70°  
 GEOLOGIST: T. DRITCO DRLG FLUID: \_\_\_\_\_ WEATHER: Sunny  
 COMMENTS: Start 1400 Sample 1430 Location 5'E of MP8-B

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	Flow Speed PID (ppm)	TLV (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
	1			Fill								
				Silty sand w/ clay lenses								
				Light brown & gray								
	5			Sandy clays w/ bricks								
				fragments								
				Light odor								
	10			Sandy clays w/ clay lenses								
				Sand LUMP present	1	12'						
	15											
	20											
	25											
	30											
	35											

## NOTES

bgs - Below Ground Surface  
 GS - Ground Surface  
 TOC - Top of Casing  
 NS - Not Sampled  
 SAA - Same As Above  
 U - Undetected

## SAMPLE TYPE

D - DRIVE  
 C - CORE  
 G - GRAB

▼ Water level drilled

## GEOLOGIC BORING LOG

Risk-Based Approach to Remediation

**PARSONS  
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

# GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: 98P05B4 CONTRACTOR: Parsons ES DATE SPUD: 12/11/98  
 CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL: \_\_\_\_\_  
 JOB NO.: 731854.0400 DRLG METHOD: 1 ELEVATION: 180 ± MSL  
 LOCATION: \_\_\_\_\_ BORING DIA.: 2" TEMP: 60°-70°  
 GEOLOGIST: T. DRAGOW DRLG FLUID: \_\_\_\_\_ WEATHER: Sunny  
 COMMENTS: Sta A 1D10 Sampled 110' Location = 15' SW of MW8-18

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	H <sub>2</sub> O SOL PID (ppm)	TLV (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
	1			Fill								
				Silty Sands								
				Brown & Gray								
				no odor								
	5											
	10			Moderate odor								
	15			Dark clay lens stand odor								
				Sand Light gray								
				Strong odor								
	20											
	25											
	30											
	35											

## NOTES

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 GS - Ground Surface  
 TOC - Top of Casing  
 NS - Not Sampled  
 SAA - Same As Above  
 U - Undetected

## SAMPLE TYPE

D - DRIVE  
 C - CORE  
 G - GRAB

▼ Water level drilled

## GEOLOGIC BORING LOG

Risk-Based Approach to Remediation

**PARSONS  
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

# GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: 8POS35 CONTRACTOR: Parsons DATE SPUD: 12/11/97  
 CLIENT: AFLE RIG TYPE: Geoprobe DATE CMPL:   
 JOB NO.: 731854.0400 DRLG METHOD: 1 ELEVATION: 180 ± MSL  
 LOCATION:  BORING DIA.: 2" TEMP: 60°-70°  
 GEOLOGIST: T. DRAGAGE DRLG FLUID:  WEATHER: Sunny  
 COMMENTS: Shot 0730 Sample 0815

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			Fill Sand / silty sand in brown								
	5			Silty Sands Brown to L. Gray								
	10			Silty Sands								
	12			Clay Silty clay		12'	Lim					
	15											
	20			Location = 5' NW of MW8-06								
	25											
	30											
	35											

## NOTES

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 GS - Ground Surface  
 TOC - Top of Casing  
 NS - Not Sampled  
 SAA - Same As Above  
 U - Undetected

## SAMPLE TYPE

D - DRIVE  
 C - CORE  
 G - GRAB

▼ Water level drilled

## GEOLOGIC BORING LOG

Risk-Based Approach to Remediation

**PARSONS  
 ENGINEERING SCIENCE, INC.**

Denver, Colorado



## Sheet 1 of 1

GEOLOGIC BORING LOG			
BORING NO.:	98P05B6	CONTRACTOR:	Persons ES
CLIENT:	AFLEE	RIG TYPE:	Geoprobe
JOB NO.:	72454.0420	DRLG METHOD:	↓
LOCATION:		BORING DIA.:	2"
GEOLOGIST:	T. DRAGAS	DRLG FLUID:	
COMMENTS:	Start 0830	Sample	0900
		DATE SPUD:	12/11/98
		DATE CMLP:	
		ELEVATION:	180 + msl
		TEMP:	60° - 70°
		WEATHER:	☁️

[illegible]

## NOTES

bgs – Below Ground Surface  
GS – Ground Surface  
TOC – Top of Casing  
NS – Not Sampled  
SAA – Same As Above  
U – Undetected

SAMPLE TYPE

D - DRIVE  
C - CORE  
G - GRAB



Water level drilled

# GEOLOGIC BORING LOG

## Risk-Based Approach to Remediation

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

# MONITORING WELL CONSTRUCTION RECORD

Job Number: 731854, 104020

Location MP8-C

Well Identification \_\_\_\_\_

Job Name:

by T. DRALOW

Date: 11-8-98

Measurement Datum \_\_\_\_\_

## Pre-Development Information

Time (Start): 0830

Water Level: \_\_\_\_\_

Total Depth of Well: \_\_\_\_\_

## Water Characteristics

Color \_\_\_\_\_ Clear Cloudy

Odor: None Weak Moderate Strong

Any Films or Immiscible Material \_\_\_\_\_

pH \_\_\_\_\_ Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

## Interim Water Characteristics

Gallons Removed \_\_\_\_\_

pH \_\_\_\_\_

Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

$TD = 20' 4''$  bss

Screen =  $20' 4''$  to  $15' 4''$  bss

Note: Sand Collapse =  $16'$  bss

Sand =  $16' - 7\frac{1}{2}'$  bss

Ben. note =  $7\frac{1}{2}' - 6''$  bss

Sand =  $6'' - 0$

Initial H<sub>2</sub>O level =  $19'$  bss

## Post-Development Information

Time (Finish): 0930

Water Level: \_\_\_\_\_

Total Depth of Well: \_\_\_\_\_

Approximate Volume Removed: \_\_\_\_\_

## Water Characteristics

Color \_\_\_\_\_ Clear Cloudy

Odor: None Weak Moderate Strong

Any Films or Immiscible Material \_\_\_\_\_

pH \_\_\_\_\_ Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

Comments:

# MONITORING WELL CONSTRUCTION RECORD

Job Number: 731854, 04000

Location MP8-B

Well Identification \_\_\_\_\_

Job Name:

by T. DRAGON

Date: 11-8-88

Measurement Datum \_\_\_\_\_

## Pre-Development Information

Time (Start): 1000

Water Level: \_\_\_\_\_

Total Depth of Well: \_\_\_\_\_

## Water Characteristics

Color \_\_\_\_\_ Clear Cloudy

Odor: None Weak Moderate Strong

Any Films or Immiscible Material \_\_\_\_\_

pH \_\_\_\_\_ Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

## Interim Water Characteristics

Gallons Removed \_\_\_\_\_

pH \_\_\_\_\_

Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

*TD = 21' 6" bgs*  
*Screen = 21' 6" - 16' 6" bgs*  
*Nett Sand pack = 17' bgs*  
*Int. H<sub>2</sub>O = 18.5' bgs*  
*Sand = 13' bgs*  
*Bentonite = 13' - 1' bgs*  
*Sand 1' - 0 bgs*

## Post-Development Information

Time (Finish): 1100

Water Level: \_\_\_\_\_

Total Depth of Well: \_\_\_\_\_

Approximate Volume Removed: \_\_\_\_\_

## Water Characteristics

Color \_\_\_\_\_ Clear Cloudy

Odor: None Weak Moderate Strong

Any Films or Immiscible Material \_\_\_\_\_

pH \_\_\_\_\_ Temperature (°C) \_\_\_\_\_

Specific Conductance (µS/cm) \_\_\_\_\_

Dissolved Oxygen (mg/L) \_\_\_\_\_

Redox (mV) \_\_\_\_\_

Comments:

**APPENDIX D**  
**TIER 1 AND TIER 2 SCREENING CRITERIA**

## **TIER 1 SCREENING CRITERIA**

Table 4  
Maximum Soil Contaminant Concentrations\*

Compound	CAS #	Residential (mg/kg)	Industrial/ Commercial (mg/kg)	Soil-to- Groundwater (mg/kg)
<b>Alkanes</b>				
C5-C8	—	939	24528	72
C9-C12	—	9386	245280	3255
C9-C18	—	9386	245280	424799
C19-C36	—	93860	Health-based level > 100%	Considered immobile
Acenaphthene	83-32-9	940	24000	8
Acenaphthylene	208-96-8	469	12264	11
Anthracene	120-12-7	4600	122000	995
<b>Aromatics</b>				
C9-C10	—	469	12264	34
C11-C22	—	469	12264	206
Benzene	71-43-2	22	200	0.0056
Benzo(a)anthracene	56-55-3	0.88	8	0.34
Benzo(b)fluoranthene	205-99-2	0.88	8	1
Benzo(g,h,i)perylene	191-24-2	469	12264	6720
Benzo(k)fluoranthene	207-08-9	9	78	12
Benzo(a)pyrene	50-32-8	0.088	0.78	0.091
n-Butylbenzene	104-51-8	156	4088	4
sec-Butylbenzene	135-98-8	156	4088	3
tert-Butylbenzene	104-51-8	156	4088	3
n-Propylbenzene	103-65-1	156	4088	2
Chromium	7440-50-8	78	2000	27
Chrysene	218-01-9	88	780	38
Dibenz(a,h)anthracene	53-70-3	0.088	0.78	0.17
1, 2- Dibromoethane (ethylene dibromide)	106-93-4	0.0075	0.067	1.97E-06
1, 2-Dichlorobenzene	95-50-1	1400	36000	7
1, 3-Dichlorobenzene	541-73-1	1400	36000	24
1, 4-Dichlorobenzene	106-46-7	27	240	1

\*If the maximum soil contaminant concentration is less than the method detection limit, the maximum soil contaminant concentration should be set at the level of the method detection limit

Table 4 Continued - Maximum Soil Contaminant Concentrations

Compound	CAS #	Residential (mg/kg)	Industrial/ Commercial (mg/kg)	Soil-to- Groundwater (mg/kg)
1, 1-Dichloroethane	75-34-3	1560	40000	4
1, 2-Dichloroethane (ethylene dichloride)	107-06-2	7	63	0.0018
1, 2-Dichloroethene (cis)	156-59-2	156	4000	0.35
1, 2-Dichloroethene (trans)	156-60-5	320	8200	0.38
1, 1-Dichloroethylene	75-35-4	1	10	0.045
1, 2-Dichloropropane	78-87-5	9	84	0.0029
1, 3-Dichloropropene (cis and trans)	542-75-6	4	33	0.0009
Ethylbenzene	100-41-4	1560	40000	0.24
Fluoranthene	206-44-0	620	16400	276
Fluorene	86-73-7	620	16400	44
Indeno(1,2,3-cd)pyrene	193-39-5	0.88	8	3
Isopropyl benzene	98-82-8	1564	40880	2
Isopropyl ether (Diisopropyl ether)	108-20-3	156	4088	0.37
Lead	7439-92-1	400	400	270
2-Methylnaphthalene	91-57-6	63	1635	3
Methyl tert-butyl ether (MTBE)	1634-04-4	156	4088	0.92
Naphthalene	91-20-3	63	1635	0.58
Phenanthrene	85-01-8	469	12264	60
Pyrene	129-00-0	469	12264	286
1,2,4-Trimethylbenzene	95-63-6	782	20440	8
1,3,5-Trimethylbenzene	108-67-8	782	20440	7
Toluene	108-88-3	3200	82000	7
Xylenes (mixed)	1330-20-7	32000	200000	5

\*If the maximum soil contaminant concentration is less than the method detection limit, the maximum soil contaminant concentration should be set at the level of the method detection limit.

Table 7  
Gross Contamination Levels for Groundwater

Compound	CAS #	GCL (ug/L)	BASIS
Acenaphthene	83-32-9	2120	SOL
Acenaphthylene	208-96-8	1965	SOL
Anthracene	120-12-7	645	SOL
Benzene	71-43-2	5000	DWSTD
Benzo(a)anthracene	56-55-3	22	SOL
Benzo(b)fluoranthene -	205-99-2	0.6 -	SOL
Benzo(g,h,i)perylene	191-24-2	210	SOL
Benzo(k)fluoranthene	207-08-9	0.47 -	SOL
Benzo(a)pyrene	50-32-8	1.5 -	SOL
n-Butylbenzene -	104-51-8	6900	SOL
sec-Butylbenzene -	135-98-8	8500	SOL
tert-Butylbenzene -	104-51-8	15000	SOL
Chromium	7440-50-8	50	SOL
Chrysene	218-01-9	5 -	SOL
Dibenz(a,h)anthracene -	53-70-3	0.25 -	SOL
1, 2-Dibromoethane (ethylene dibromide) -	106-93-4	50	DWSTD
1, 2-Dichlorobenzene -	95-50-1	72500	SOL
1, 3-Dichlorobenzene -	541-73-1	61500	SOL
1, 4-Dichlorobenzene -	106-46-7	39500	SOL
1, 1-Dichloroethane -	75-34-3	700000	STD
1, 2-Dichloroethane (ethylene dichloride) -	107-06-2	380	STD
1, 1-Dichloroethylene -	75-35-4	7000	STD
1, 2-Dichloroethene (cis) -	156-59-2	70000	STD
1, 2-Dichloroethene (trans) -	156-60-5	70000	STD
1, 2-Dichloropropane -	78-87-5	560	STD
1, 3-Dichloropropene (cis and trans) -	542-75-6	200	STD
Ethylbenzene	100-41-4	29000	STD
Fluoranthene	206-44-0	280	SOL
Fluorene	86-73-7	950	SOL
Indeno(1,2,3-cd)pyrene	193-39-5	31	SOL
Isopropyl benzene	98-82-8	25000	SOL
Isopropyl ether (Diisopropyl ether) -	108-20-3	70000	STD
Lead -	7439-92-1	15	SOL
2-Methylnaphthalene	91-57-6	12500	STD
Methyl tert-butyl ether (MTBE) -	1634-04-4	200000	STD
Naphthalene	91-20-3	15500	SOL
Phenanthrene	85-01-8	410	SOL
n-Propylbenzene -	103-65-1	30000	SOL
Pyrene	129-00-0	210	SOL
Toluene	108-88-3	257500	SOL
1,2,4-Trimethylbenzene -	95-63-6	28500	SOL
1,3,5-Trimethylbenzene -	108-67-8	25000	SOL
Xylenes (mixed)	1330-20-7	87500	SOL

SOL - 50% of the solubility at 25 degrees Celsius

DWSTD - 1000 x federal drinking water standard (40 CFR 141)

STD - 1000 x North Carolina groundwater quality standard (15A NCAC 2L .0202)



**TIER 2 SSTLs FOR**  
**BENZO(B)FLUORANTHENE AND**  
**BENZO(K)FLUORANTHENE**

**CALCULATION OF SITE-SPECIFIC TARGET LEVELS - GROUNDWATER <sup>u</sup>**  
**INDUSTRIAL LAND USE ASSUMPTIONS – CONSTRUCTION SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

**Exposure Assumptions**

**Receptor**

Site-specific target level for combined exposure routes (SSTL)  
 Site-specific target level based on incidental ingestion of groundwater (SSTL<sub>ing</sub>)  
 Site-specific target level based on dermal contact with groundwater (SSTL<sub>derm</sub>)  
 Site-specific target level based on aboveground inhalation of contaminants volatilized from groundwater (SSTL<sub>inhal-above</sub>)  
 Site-specific target level based on inhalation of contaminants volatilized from groundwater into the trench (SSTL<sub>inhal-trench</sub>)

**Construction Worker**

chem.-specific  $\mu\text{g/L}$  <sup>u</sup>  
 chem.-specific  $\mu\text{g/L}$   
 chem.-specific  $\mu\text{g/L}$   
 chem.-specific  $\mu\text{g/L}$   
 chem.-specific  $\mu\text{g/L}$

**SSTL Equation (combined exposure routes)**

$$SSTL = \frac{1}{\frac{1}{SSTL_{ing}} + \frac{1}{SSTL_{derm}} + \frac{1}{SSTL_{inhal-above}} + \frac{1}{SSTL_{inhal-trench}}}$$

CAS	RME SCENARIO <sup>d</sup>					CT SCENARIO <sup>e</sup>					
	SSTL <sub>ing</sub> (μg/L)	SSTL <sub>derm</sub> (μg/L)	SSTL <sub>inhal-above</sub> (μg/L)	SSTL <sub>inhal-trench</sub> (μg/L)	SSTL <sub>RME</sub> (μg/L)	SSTL <sub>ing</sub> (μg/L)	SSTL <sub>derm</sub> (μg/L)	SSTL <sub>inhal-above</sub> (μg/L)	SSTL <sub>inhal-trench</sub> (μg/L)	SSTL <sub>CT</sub> (μg/L)	
Contaminant	Number <sup>d</sup>										
Polynuclear Aromatic Hydrocarbons											
Benzo(b)fluoranthene	205-99-2	5.33E+03	4.39E+00	3.06E+06	1.43E+04	4.39E+00	6.53E+04	3.47E+01	9.11E+06	4.38E+04	3.47E+01
Benzo(k)fluoranthene	207-08-9	5.33E+04	4.39E+01	2.13E+09	8.77E+06	4.39E+01	6.53E+05	3.47E+02	6.33E+09	2.69E+07	3.47E+02

<sup>u</sup> SSTL calculations based on combining the following exposure routes: incidental ingestion, dermal contact, inhalation of contaminants volatilized from groundwater into aboveground ambient air, and inhalation of contaminants volatilized from groundwater into ambient air in a trench/excavation pit.

<sup>d</sup> CAS = Chemical Abstracts Service number.

<sup>u</sup>  $\mu\text{g/L}$  = micrograms per liter

<sup>u</sup> RME = reasonable maximum exposure

<sup>u</sup> CT = central tendency

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INGESTION OF GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Exposure Assumptions		PRG Equations	
Receptor	Construction Worker: RME Scenario	Carcinogenic:	
Site-specific target level based on incidental ingestion of groundwater ( $SSTL_{ing}$ )	chemical-specific $\mu\text{g/L}$ <sup>a</sup>	$SSTL_{ing-c} = \frac{(TR)(BW)(AT_c)(365 \text{ day / year})}{(SF)(IR_w)(EF)(ED)(ET)(CF)}$	
Target cancer risk level (TR)	1.00E-06 unitless		
Body Weight (BW)	70 kg		
Averaging Time, Carcinogens ( $AT_c$ )	70 yrs		
Oral Slope Factor ( $SF_o$ )	chemical-specific (mg/kg-day) <sup>-1</sup> <sup>b</sup>	Noncarcinogenic:	
Water Ingestion Rate ( $IR_w$ )	0.005 L/hr		
Exposure Frequency (EF)	46 days/yr		
Exposure Duration (ED)	1 yr		
Exposure Time (ET)	2 hrs/day		
Conversion Factor (CF)	0.001 mg/ $\mu\text{g}$		
Target hazard quotient (THQ)	1 unitless		
Oral Reference Dose ( $RfD_o$ )	chemical-specific mg/kg-day	$SSTL_{ing-nc} = \frac{(THQ)(BW)(RfD_o)(AT_{nc})(365 \text{ day / year})}{(IR_w)(EF)(ED)(ET)(CF)}$	
Averaging Time, Noncarcinogens ( $AT_{nc}$ )	1 yr		

Contaminant	CAS Number <sup>d</sup>	SF <sub>o</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>o</sub> (mg/kg-day)	SSTL <sub>ing-c</sub> ( $\mu\text{g/L}$ )	SSTL <sub>ing-nc</sub> ( $\mu\text{g/L}$ )	SSTL <sub>ing</sub> ( $\mu\text{g/L}$ )
Polynuclear Aromatic Hydrocarbons						
Benzo(b)fluoranthene	205-99-2	7.30E-01	-- <sup>a</sup>	5.33E+03	--	5.33E+03
Benzo(k)fluoranthene	207-08-9	7.30E-02	--	5.33E+04	--	5.33E+04

<sup>a</sup>  $\mu\text{g/L}$  = microgram per liter  
<sup>b</sup> mg/kg-day = milligram per kilogram-day  
<sup>c</sup> CAS = Chemical Abstracts Service number.  
<sup>d</sup> -- = toxicity data not available.

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INGESTION OF GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - CT SCENARIO**  
 SITE ST-08 (BUILDING 41105)  
 POPE AFB, NORTH CAROLINA

Exposure Assumptions		PRG Equations	
Receptor	Construction Worker: CT Scenario	Carcinogenic:	
Site-specific target level based on incidental ingestion of groundwater ( $SSTL_{ing}$ )			
Target cancer risk level (TR)	chemical-specific $\mu\text{g/L}$ <sup>a</sup>	$SSTL_{ing-c} = \frac{(TR)(BW)(AT_c)(365 \text{ day / year})}{(SF_o)(IR_w)(EF)(ED)(ET)(CF)}$	
Body Weight (BW)	1.00E-06 unitless		
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 kg		
Oral Slope Factor (SF <sub>o</sub> )	70 yrs		
Water Ingestion Rate (IR <sub>w</sub> )	chemical-specific (mg/kg-day) <sup>b</sup>	Noncarcinogenic:	
Exposure Frequency (EF)	0.0025 L/hr		
Exposure Duration (ED)	15 days/yr		
Exposure Time (ET)	1 yr		
Conversion Factor (CF)	1 hrs/day		
Target hazard quotient (THQ)	0.001 mg/ $\mu\text{g}$	$SSTL_{ing-nc} = \frac{(THQ)(BW)(RfD_o)(AT_{nc})(365 \text{ day / year})}{(IR_w)(EF)(ED)(ET)(CF)}$	
Oral Reference Dose (RfD <sub>o</sub> )	1 unitless		
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	chemical-specific mg/kg-day		
	1 yr		

Contaminant	CAS Number <sup>d</sup>	SF <sub>o</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>o</sub> (mg/kg-day)	SSTL <sub>ing-c</sub> ( $\mu\text{g/L}$ )	SSTL <sub>ing-nc</sub> ( $\mu\text{g/L}$ )	SSTL <sub>ing</sub> ( $\mu\text{g/L}$ )
Polynuclear Aromatic Hydrocarbons						
Benzo(b)fluoranthene	205-99-2	7.30E-01	-- <sup>d</sup>	6.53E+04	--	6.53E+04
Benzo(k)fluoranthene	207-08-9	7.30E-02	--	6.53E+05	--	6.53E+05

<sup>a</sup>  $\mu\text{g/L}$  = microgram per liter  
<sup>b</sup> mg/kg-day = milligram per kilogram-day  
<sup>c</sup> CAS = Chemical Abstracts Service number.  
<sup>d</sup> -- = toxicity data not available.

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON DERMAL CONTACT WITH GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
 SITE ST-08 (BUILDING 41105)  
 POPE AFB, NORTH CAROLINA

Input Parameters		PRG Equations	
Receptor	Construction Worker: RME Scenario	For inorganics:	
Site-specific target level based on dermal contact with groundwater (SSTL <sub>derm</sub> )			
Dose absorbed per unit area per event (DA <sub>event</sub> )	chemical-specific $\mu\text{g/L}^u$	$SSTL_{derm-inorg} = \frac{(DA_{event})(CF)}{(K_p)(t_{event})}$	
Conversion Factor (CF)	chemical-specific $\text{mg}/\text{cm}^2\text{-event}^u$		
Permeability coefficient from water (K <sub>p</sub> )	1.00E+06 (ml/L) x (μg/mg) <sup>v</sup>		
Duration of event (t <sub>event</sub> )	Chemical-specific $\text{cm}/\text{hr}^d$		
Time it takes to reach steady state (t*)	2 hr/event <sup>e</sup>		
Lag time per event (t <sub>event</sub> )	Chemical-specific hr/event		
Relative contribution of permeability coefficients in stratum corneum and viable epidermis (B)	Chemical-specific hr/event		
	Chemical-specific unitless		

If t<sub>event</sub> < t\*, then:

$$SSTL_{derm-org} = \frac{(DA_{event})(CF)}{2K_p \sqrt{\frac{6\tau_{event} t_{event}}{\pi}}}$$

If t<sub>event</sub> > t\*, then:

$$SSTL_{derm-org} = \frac{(DA_{event})(CF)}{K_p \left[ \frac{t_{event}}{1+B} + 2\tau_{event} \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right]}$$

Contaminant	Type <sup>v</sup>	K <sub>p</sub> (cm/hr)	t* (hr/event)	τ <sub>event</sub> (hr/event)	B (unitless)	DA <sub>event</sub> (mg/cm <sup>2</sup> -event)	SSTL <sub>derm-z</sub> (μg/L)	SSTL <sub>derm-sc</sub> (μg/L)	SSTL <sub>derm</sub> (μg/L)
Polynuclear Aromatic Hydrocarbons									
Benzo(b)fluoranthene	o	1.95E-01	1.43E+01	3.03E+00	1.58E+02	5.83E-06	-- <sup>v</sup>	4.39E+00	4.39E+00
Benzo(k)fluoranthene	o	1.95E-01	1.43E+01	3.03E+00	1.58E+02	5.83E-05	--	4.39E+01	4.39E+01

<sup>u</sup> μg/L = micrograms per liter

<sup>w</sup> mg/cm<sup>2</sup>-event = milligrams per centimeter-event

<sup>v</sup> (ml/L) x (μg/mg) = milliliter per liter times microgram per milligram

<sup>d</sup> cm/hr = centimeters per hour

<sup>e</sup> hr/event = hours per event

<sup>f</sup> "o" indicates an organic compound, "i" indicates an inorganic compound

<sup>g</sup> "--" = toxicity data not available.

**DA<sub>event</sub> CALCULATIONS FOR DERMAL CONTACT WITH GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Exposure Assumptions		DA <sub>event</sub> Equations	
Receptor	Construction Worker: RME Scenario	Carcinogenic:	
Dose absorbed per unit area per event (DA <sub>event</sub> )	chemical-specific mg/cm <sup>2</sup> -event <sup>a</sup>		
Target cancer risk level (TR)	1.00E-06 unitless		
Body Weight (BW)	70 kg		
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs		
Dermal Slope Factor (SF <sub>d</sub> ) (i.e., SF <sub>o</sub> adjusted for GI absorption)	chemical-specific (mg/kg-day) <sup>-1</sup> <sup>a</sup>		
Exposure Frequency (EF)	46 days/yr <sup>d</sup>		
Exposure Duration (ED)	1 yr		
Event Frequency (EV)	1 events/day		
Fraction of Estimated Time in Contact with Water (EC)	1 unitless		
Exposed Body Surface Area (SA)	5300 cm <sup>2</sup>		
Target hazard quotient (THQ)	1 unitless		
Dermal Reference Dose (RfD <sub>d</sub> ) (i.e., RfD <sub>o</sub> adjusted for GI absorption)	chemical-specific mg/kg-day		
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr		

$$DA_{event_{carc}} = \frac{(TR)(BW)(AT_c)(365day/year)}{(SF_d)(EF)(ED)(EV)(EC)(SA)}$$

where  $SF_d = \frac{(SF_o)}{(OAF)}$  and: OAF = Oral GI absorption factor (chemical-specific; unitless)

Noncarcinogenic:

$$DA_{event_{nc}} = \frac{(THQ)(BW)(RfD_d)(AT_{nc})(365day/year)}{(EF)(ED)(EV)(EC)(SA)}$$

where  $RfD_d = (RfD_o)(OAF)$

Contaminant	CAS Number <sup>a</sup>	SF <sub>o</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>o</sub> (mg/kg-day)	OAF (unitless)	SF <sub>d</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>d</sub> (mg/kg-day)	DA <sub>event_{carc}</sub> (mg/cm <sup>2</sup> -event)	DA <sub>event_{nc}</sub> (mg/cm <sup>2</sup> -event)	DA <sub>event</sub> (mg/cm <sup>2</sup> -event)
Polynuclear Aromatic Hydrocarbons									
Benzo(b)fluoranthene	205-99-2	7.30E-01	-- <sup>d</sup>	5.80E-01	1.26E+00	--	5.83E-06	--	5.83E-06
Benzo(k)fluoranthene	207-08-9	7.30E-02	--	5.80E-01	1.26E-01	--	5.83E-05	--	5.83E-05

<sup>a</sup> mg/cm<sup>2</sup> = milligram per square centimeter.

<sup>b</sup> mg/kg-day = milligram per kilogram-day

<sup>c</sup> days/yr = days per year

<sup>d</sup> CAS = Chemical Abstracts Service number.

<sup>e</sup> -- = toxicity data not available.

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON DERMAL CONTACT WITH GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - CT SCENARIO**  
 SITE ST-08 (BUILDING 41105)  
 POPE AFB, NORTH CAROLINA

Input Parameters		PRG Equations	
Receptor	Construction Worker: CT Scenario	For inorganics:	
Site-specific target level based on dermal contact with groundwater (SSTL <sub>derm</sub> )			
Dose absorbed per unit area per event (DA <sub>event</sub> )	chemical-specific $\mu\text{g/L}^u$	$\text{SSTL}_{\text{derm-inorg}} = \frac{(DA_{\text{event}})(CF)}{(K_p)(t_{\text{event}})}$	
Conversion Factor (CF)	chemical-specific $\text{mg}/\text{cm}^2\text{-event}^w$		
Permeability coefficient from water (K <sub>p</sub> )	1.00E+06 (ml/L) x (μg/mg) <sup>v</sup>		
Duration of event (t <sub>event</sub> )	Chemical-specific $\text{cm}/\text{hr}^d$	For organics:	
Time it takes to reach steady state (t*)	1 hr/event <sup>d</sup>	If t <sub>event</sub> < t*, then:	
Lag time per event (t <sub>event</sub> )	Chemical-specific hr/event	$\text{SSTL}_{\text{derm-org}} = \frac{(DA_{\text{event}})(CF)}{2K_p \sqrt{\frac{6\tau_{\text{event}} t_{\text{event}}}{\pi}}}$	
Relative contribution of permeability coefficients in stratum corneum and viable epidermis (B)	Chemical-specific hr/event	If t <sub>event</sub> > t*, then:	
	Chemical-specific unitless	$\text{SSTL}_{\text{derm-org}} = \frac{(DA_{\text{event}})(CF)}{K_p \left[ \frac{t_{\text{event}}}{1+B} + 2\tau_{\text{event}} \left( \frac{1+3B+3B^2}{(1+B)^2} \right) \right]}$	

Contaminant	Type <sup>u</sup>	K <sub>p</sub> (cm/hr)	t* (hr/event)	t <sub>event</sub> (hr/event)	B (unitless)	DA <sub>event</sub> (mg/cm <sup>2</sup> -event)	SSTL <sub>derm-c</sub> (μg/L)	SSTL <sub>derm-inc</sub> (μg/L)	SSTL <sub>derm</sub> (μg/L)
Polynuclear Aromatic Hydrocarbons									
Benzo(b)fluoranthene	o	1.95E-01	1.43E+01	3.03E+00	1.58E+02	3.26E-05	-- <sup>v</sup>	3.47E+01	3.47E+01
Benzo(k)fluoranthene	o	1.95E-01	1.43E+01	3.03E+00	1.58E+02	3.26E-04	--	3.47E+02	3.47E+02

<sup>u</sup> μg/L = micrograms per liter  
<sup>w</sup> mg/cm<sup>2</sup>-event = milligrams per centimeter-event  
<sup>v</sup> (ml/L) x (μg/mg) = milliliter per liter times microgram per milligram  
<sup>d</sup> cm/hr = centimeters per hour  
<sup>e</sup> hr/event = hours per event  
<sup>o</sup> "o" indicates an organic compound, "\*" indicates an inorganic compound  
<sup>v</sup> "--" = toxicity data not available.

**DA<sub>event</sub> CALCULATIONS FOR DERMAL CONTACT WITH GROUNDWATER  
INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - CT SCENARIO**  
SITE ST-08 (BUILDING 41105)  
POPE AFB, NORTH CAROLINA

Exposure Assumptions		DA <sub>event</sub> Equations	
Receptor	Construction Worker: CT Scenario	Carcinogenic:	
Dose absorbed per unit area per event (DA <sub>event</sub> )	chemical-specific mg/cm <sup>2</sup> -event <sup>w</sup>		
Target cancer risk level (TR)	1.00E-06 unitless		
Body Weight (BW)	70 kg		
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs		
Dermal Slope Factor (SF <sub>d</sub> ) (i.e., SF <sub>o</sub> adjusted for GI absorption)	chemical-specific (mg/kg-day) <sup>-1</sup> w		
Exposure Frequency (EF)	15 days/yr <sup>d</sup>		
Exposure Duration (ED)	1 yr		
Event Frequency (EV)	1 events/day		
Fraction of Estimated Time in Contact with Water (EC)	1 unitless		
Exposed Body Surface Area (SA)	2910 cm <sup>2</sup>		
Target hazard quotient (THQ)	1 unitless		
Dermal Reference Dose (RfD <sub>d</sub> ) (i.e., RfD <sub>o</sub> adjusted for GI absorption)	chemical-specific mg/kg-day		
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr		

$$DA_{event\_carc} = \frac{(TR)(BW)(AT_c)(365day/year)}{(SF_d)(EF)(ED)(EV)(EC)(SA)}$$

where  $SF_d = \frac{(SF_o)}{(OAF)}$  and: OAF = Oral GI absorption factor (chemical-specific; unitless)

Noncarcinogenic:

$$DA_{event\_nc} = \frac{(THQ)(BW)(RfD_d)(AT_{nc})(365day/year)}{(EF)(ED)(EV)(EC)(SA)}$$

where  $RfD_d = (RfD_o)(OAF)$

Contaminant	CAS Number <sup>w</sup>	SF <sub>o</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>o</sub> (mg/kg-day)	OAF (unitless)	SF <sub>d</sub> (mg/kg-day) <sup>-1</sup>	RfD <sub>d</sub> (mg/kg-day)	DA <sub>event</sub> <sub>carc</sub> (mg/cm <sup>2</sup> -event)	DA <sub>event</sub> <sub>nc</sub> (mg/cm <sup>2</sup> -event)	DA <sub>event</sub> (mg/cm <sup>2</sup> -event)
Polynuclear Aromatic Hydrocarbons									
Benzo(b)fluoranthene	205-99-2	7.30E-01	-- <sup>d</sup>	5.80E-01	1.26E+00	--	3.26E-05	--	3.26E-05
Benzo(k)fluoranthene	207-08-9	7.30E-02	--	5.80E-01	1.26E-01	--	3.26E-04	--	3.26E-04

<sup>w</sup> mg/cm<sup>2</sup> = milligram per square centimeter.  
<sup>v</sup> mg/kg-day = milligram per kilogram-day  
<sup>d</sup> days/yr = days per year  
<sup>w</sup> CAS = Chemical Abstracts Service number.  
<sup>d</sup> -- = toxicity data not available.



**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INHALATION OF VOLATILES FROM GROUNDWATER: ABOVEGROUND  
INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
SITE ST-08 (BUILDING 41105)  
POPE AFB, NORTH CAROLINA

Exposure Assumptions		SSTL Equations
Receptor	Construction Worker: RME Scenario	Carcinogenic:
Site-specific target level: aboveground inhalation of volatiles from groundwater (SSTL <sub>inh</sub> )	chemical-specific $\mu\text{g}/\text{L}^u$	
Target cancer risk level (TR)	1.00E-06 unitless	
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs	$SSTL_{inh-c} = \frac{(TR)(AT_c)(365\text{day/year})}{(URF)(EF)(ED)(FT)(VF_{wamb})}$
Inhalation unit risk factor (URF)	chemical-specific $(\mu\text{g}/\text{m}^3)^{-1}\text{yr}$	
Exposure Frequency (EF) (180 - 46 days/year = 134 days/year aboveground)	134 days/yr	
Exposure Duration (ED)	1 yr	
Fraction of time breathing aboveground contaminated air during a 24 hour day (FT) (8 hr/24 hr)	0.3 unitless	Noncarcinogenic:
Cross-media groundwater-to-air (outdoor) air volatilization factor (VF <sub>wamb</sub> )	chemical-specific $(\text{mg}/\text{m}^3\text{-air})/(\text{mg}/\text{L-water})^u$	
Target hazard quotient (THQ)	1 unitless	
Inhalation reference concentration (RfC)	chemical-specific $\mu\text{g}/\text{m}^3$	$SSTL_{inh-nc} = \frac{(THQ)(RfC)(AT_{nc})(365\text{day/year})}{(EF)(ED)(FT)(VF_{wamb})}$
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr	

Contaminant	CAS Number <sup>d/</sup>	Chemical Type <sup>d/</sup>	URF $(\mu\text{g}/\text{m}^3)^{-1}$	RfC $(\mu\text{g}/\text{m}^3)$	VF <sub>wamb</sub>	SSTL <sub>inh-c</sub> $(\mu\text{g}/\text{L})$	SSTL <sub>inh-nc</sub> $(\mu\text{g}/\text{L})$	SSTL <sub>inh</sub> $(\mu\text{g}/\text{L})$
Polynuclear Aromatic Hydrocarbons								
Benzo(b)fluoranthene	205-99-2	0	8.80E-05	-- <sup>u</sup>	2.12E-06	3.06E+06	--	3.06E+06
Benzo(k)fluoranthene	207-08-9	0	8.80E-06	--	3.06E-08	2.13E+09	--	2.13E+09

<sup>d/</sup>  $\mu\text{g}/\text{L}$  = microgram per liter  
<sup>m</sup>  $\mu\text{g}/\text{m}^3$  = microgram per cubic meter  
<sup>d/</sup>  $(\text{mg}/\text{m}^3\text{-air})/(\text{mg}/\text{L-water})$  = (milligram per cubic meter air) per (milligram per liter water)  
<sup>d/</sup> CAS = Chemical Abstracts Service number.  
<sup>d/</sup> "o" = organic; "i" = inorganic  
<sup>u</sup> -- = toxicity data not available.

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INHALATION OF VOLATILES FROM GROUNDWATER: ABOVEGROUND  
INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO  
SITE ST-08 (BUILDING 41105)  
POPE AFB, NORTH CAROLINA**

Exposure Assumptions		SSTL Equations	
Receptor	Construction Worker: RME Scenario	Carcinogenic:	
Site-specific target level: aboveground inhalation of volatiles from groundwater (SSTL <sub>inh</sub> )	chemical-specific $\mu\text{g/L}$ <sup>a</sup>		
Target cancer risk level (TR)	1.00E-06 unitless		
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs	$SSTL_{inh-c} = \frac{(TR)(AT_c)(365\text{day/yr})}{(URF)(EF)(ED)(FT)(VF_{wamb})}$	
Inhalation unit risk factor (URF)	chemical-specific ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup> <sup>b</sup>		
Exposure Frequency (EF) (60 - 15 days/year = 45 days/year aboveground)	45 days/yr		
Exposure Duration (ED)	1 yr		
Fraction of time breathing aboveground contaminated air during a 24 hour day (FT) (8 hr/24 hr)	0.3 unitless	Noncarcinogenic:	
Cross-media groundwater-to-air (outdoor) air volatilization factor (VF <sub>wamb</sub> )	chemical-specific ( $\text{mg}/\text{m}^3\text{-air}/(\text{mg}/\text{L-water})$ ) <sup>c</sup>		
Target hazard quotient (THQ)	1 unitless		
Inhalation reference concentration (RfC)	chemical-specific $\mu\text{g}/\text{m}^3$	$SSTL_{inh-nc} = \frac{(THQ)(RfC)(AT_{nc})(365\text{day/yr})}{(EF)(ED)(FT)(VF_{wamb})}$	
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr		

Contaminant	CAS Number <sup>d</sup>	Chemical Type <sup>e</sup>	URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	RfC ( $\mu\text{g}/\text{m}^3$ )	VF <sub>wamb</sub>	SSTL <sub>inh-c</sub> ( $\mu\text{g}/\text{L}$ )	SSTL <sub>inh-nc</sub> ( $\mu\text{g}/\text{L}$ )	SSTL <sub>inh</sub> ( $\mu\text{g}/\text{L}$ )
<b>Polynuclear Aromatic Hydrocarbons</b>								
Benzo(b)fluoranthene	205-99-2	0	8.80E-05	— <sup>f</sup>	2.12E-06	9.11E+06	—	9.11E+06
Benzo(k)fluoranthene	207-08-9	0	8.80E-06	—	3.06E-08	6.33E+09	—	6.33E+09

<sup>a</sup>  $\mu\text{g}/\text{L}$  = microgram per liter  
<sup>b</sup>  $\mu\text{g}/\text{m}^3$  = microgram per cubic meter  
<sup>c</sup> ( $\text{mg}/\text{m}^3\text{-air}/(\text{mg}/\text{L-water})$ ) = (milligram per cubic meter air) per (milligram per liter water)  
<sup>d</sup> CAS = Chemical Abstracts Service number.  
<sup>e</sup> "0" = organic; "\*" = inorganic  
<sup>f</sup> — = toxicity data not available.

[illegible]

<sup>v</sup> (mg/m<sup>3</sup>-air)/(mg/L-water) = milligrams per cubic meter of air per milligrams per liter of water  
<sup>w</sup> (cm<sup>3</sup>-water)/(cm<sup>3</sup>-air) = cubic centimeters of water per cubic centimeters of air  
<sup>x</sup> cm/s = centimeters per second  
<sup>y</sup> cm = centimeter  
<sup>z</sup> cm<sup>2</sup>/s = square centimeters per second  
<sup>u</sup> cm<sup>3</sup>-air/cm<sup>3</sup>-total volume = cubic centimeters air per cubic centimeters total volume  
<sup>v</sup> cm<sup>3</sup>/cm<sup>3</sup>-soil = cubic centimeters per cubic centimeters-soil  
<sup>w</sup> cm<sup>3</sup>-water/cm<sup>3</sup>-soil = cubic centimeters water per cubic centimeters soil

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INHALATION OF VOLATILES IN TRENCH FROM GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Input Parameters		SSTL Equations	
Receptor	Construction Worker: RME Scenario		
Site-specific target level: inhalation of volatiles in trench from groundwater (SSTL <sub>inhal-trench</sub> )	chemical-specific $\mu\text{g/L}^w$		
Air concentration at target risk/hazard levels ( $C_{air}$ )	chemical-specific $\mu\text{g/m}^3^w$	$SSTL_{inhal-trench} = \frac{(C_{air})(LS)(V)(MH)}{(K)(A)(CF)}$	
Length of side perpendicular to wind (LS)	15 m <sup>e</sup>	where: $K = \left[ \frac{1}{K_1} + \frac{(8.2E-05 \text{ atm} \cdot \text{m}^3 / \text{mol} \cdot ^\circ \text{K})(298 \text{ K})}{(H)(K_p)} \right]^{-1}$	
Average wind speed (V)	4.47 m/s <sup>d</sup>		
Mixing height above water (MH)	2 m	and:	
Mass transfer coefficient (K)	Chemical-specific cm/s <sup>e</sup>	$K_1 = \left( \frac{32 \text{ g/mol}}{MW} \right)^{0.5} (0.0061 \text{ cm/s})$	
Area of the trench (A)	3.00E+05 cm <sup>2</sup>	$K_p = \left( \frac{18 \text{ g/mol}}{MW} \right)^{0.333} (1.39 \text{ cm/s})$	
Liquid mass transfer coefficient ( $K_p$ )	Chemical-specific cm/s		
Henry's Law Constant (H)	Chemical-specific atm-m <sup>3</sup> /mol <sup>u</sup>		
Gas mass transfer coefficient ( $K_1$ )	Chemical-specific cm/s		
Molecular weight (MW)	Chemical-specific g/mol		
Conversion Factor (CF)	0.001 L/cm <sup>3</sup>		

Contaminant	H (atm-m <sup>3</sup> /mol)	MW (g/mol)	K <sub>1</sub> (cm/s)	K <sub>p</sub> (cm/s)	K (cm/s)	C <sub>air</sub> ( $\mu\text{g/m}^3$ )	SSTL <sub>inhal-trench</sub> ( $\mu\text{g/L}$ )
<b>Polynuclear Aromatic Hydrocarbons</b>							
Benzo(b)fluoranthene	1.11E-04	252.32	2.17E-03	5.74E-01	1.18E-03	3.79E+01	1.43E+04
Benzo(k)fluoranthene	8.29E-07	252.32	2.17E-03	5.74E-01	1.93E-05	3.79E+02	8.77E+06
<sup>w</sup> $\mu\text{g/L}$ = microgram per liter <sup>w</sup> $\mu\text{g/m}^3$ = microgram per cubic meter <sup>e</sup> m = meter <sup>d</sup> m/s = meter per second <sup>e</sup> cm/s = centimeter per second <sup>u</sup> atm-m <sup>3</sup> -mol = atmosphere per cubic meter per mole							

**C<sub>air</sub> CALCULATIONS BASED ON INHALATION OF VOLATILES FROM GROUNDWATER: TRENCH**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - RME SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Exposure Assumptions	C <sub>air</sub> Equations
Receptor	Construction Worker: RME Scenario
Air concentration at target risk/hazard levels (C <sub>air</sub> )	chemical-specific $\mu\text{g}/\text{m}^3$ <sup>u</sup>
Target cancer risk level (TR)	1.00E-06 unitless
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs
Inhalation unit risk factor (URF)	chemical-specific $(\mu\text{g}/\text{m}^3)^{-1}$
Exposure Frequency (EF)	46 days/yr
Exposure Duration (ED)	1 yr
Fraction of time breathing aboveground contaminated air during a 24 hour day (FT) (assumed 1/2 of work day in trench: 4 hr/24 hr)	0.2 unitless
Target hazard quotient (THQ)	1 unitless
Inhalation reference concentration (RfC)	chemical-specific $\mu\text{g}/\text{m}^3$
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr
	Noncarcinogenic:
	$C_{air-c} = \frac{(TR)(AT_c)(365 \text{ day / year})}{(URF)(EF)(ED)(FT)}$ $C_{air-nc} = \frac{(THQ)(RfC)(AT_{nc})(365 \text{ day / year})}{(EF)(ED)(FT)}$

Contaminant	CAS Number <sup>u</sup>	Chemical Type <sup>v</sup>	URF $(\mu\text{g}/\text{m}^3)^{-1}$	RfC $(\mu\text{g}/\text{m}^3)$	C <sub>air-c</sub> $(\mu\text{g}/\text{m}^3)$	C <sub>air-nc</sub> $(\mu\text{g}/\text{m}^3)$	C <sub>air</sub> $(\mu\text{g}/\text{m}^3)$
Polynuclear Aromatic Hydrocarbons							
Benzo(b)fluoranthene	205-99-2	0	8.80E-05	-- <sup>d</sup>	3.79E+01	--	3.79E+01
Benzo(k)fluoranthene	207-08-9	0	8.80E-06	--	3.79E+02	--	3.79E+02

<sup>u</sup>  $\mu\text{g}/\text{m}^3$  = microgram per cubic meter  
<sup>v</sup> CAS = Chemical Abstracts Service number.  
<sup>d</sup> "0" = organic; "1" = inorganic  
<sup>d</sup> -- = toxicity data not available.

**SITE-SPECIFIC TARGET LEVEL CALCULATIONS BASED ON INHALATION OF VOLATILES IN TRENCH FROM GROUNDWATER**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - CT SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Input Parameters		SSTL Equations	
Receptor	Construction Worker: CT Scenario		
Site-specific target level: inhalation of volatiles in trench from groundwater (SSTL <sub>inhal-trench</sub> )	chemical-specific $\mu\text{g/L}^a$		
Air concentration at target risk/hazard levels ( $C_{air}$ )	chemical-specific $\mu\text{g}/\text{m}^3$ <sup>b</sup>	$SSTL_{inhal-trench} = \frac{(C_{air})(LS)(V)(MH)}{(K)(A)(CF)}$	
Length of side perpendicular to wind (LS)	15 m <sup>c</sup>		
Average wind speed (V)	4.47 m/s <sup>d</sup>		
Mixing height above water (MH)	2 m		
Mass transfer coefficient (K)	Chemical-specific cm/s <sup>e</sup>	where:	
Area of the trench (A)	3.00E+05 cm <sup>2</sup>	$K = \left[ \frac{1}{K_1} + \frac{(8.2E-05 \text{ atm} \cdot \text{m}^3 / \text{mol} \cdot ^\circ\text{K})(298^\circ\text{K})}{(H)(K_2)} \right]^{-1}$	
Liquid mass transfer coefficient ( $K_L$ )	Chemical-specific cm/s	and:	
Henry's Law Constant (H)	Chemical-specific atm-m <sup>3</sup> /mol <sup>f</sup>	$K_1 = \left( \frac{32 \text{ g/mol}}{MW} \right)^{0.5} (0.0061 \text{ cm/s})$	
Gas mass transfer coefficient ( $K_g$ )	Chemical-specific cm/s	$K_2 = \left( \frac{18 \text{ g/mol}}{MW} \right)^{0.335} (1.39 \text{ cm/s})$	
Molecular weight (MW)	Chemical-specific g/mol		
Conversion factor (CF)	0.001 L/cm <sup>3</sup>		

Contaminant	H (atm-m <sup>3</sup> /mol)	MW (g/mol)	K <sub>1</sub> (cm/s)	K <sub>2</sub> (cm/s)	K (cm/s)	C <sub>air</sub> ( $\mu\text{g}/\text{m}^3$ )	SSTL <sub>inhal-trench</sub> ( $\mu\text{g/L}$ )
Polynuclear Aromatic Hydrocarbons							
Benzo(b)fluoranthene	1.11E-04	252.32	2.17E-03	5.74E-01	1.18E-03	1.16E+02	4.38E+04
Benzo(k)fluoranthene	8.29E-07	252.32	2.17E-03	5.74E-01	1.93E-05	1.16E+03	2.69E+07

<sup>a</sup>  $\mu\text{g/L}$  = microgram per liter  
<sup>b</sup>  $\mu\text{g}/\text{m}^3$  = microgram per cubic meter  
<sup>c</sup> m = meter  
<sup>d</sup> m/s = meter per second  
<sup>e</sup> cm/s = centimeter per second  
<sup>f</sup> atm/m<sup>3</sup>-mol = atmosphere per cubic meter per mole

**C<sub>air</sub> CALCULATIONS BASED ON INHALATION OF VOLATILES FROM GROUNDWATER: TRENCH**  
**INDUSTRIAL LAND USE - CONSTRUCTION SCENARIO - CT SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Exposure Assumptions		C <sub>air</sub> Equations	
Receptor	Construction Worker: CT Scenario	Carcinogenic:	
Air concentration at target risk/hazard levels (C <sub>air</sub> )	chemical-specific µg/m <sup>3</sup> <sup>a/</sup>		
Target cancer risk level (TR)	1.00E-06 unitless		
Averaging Time, Carcinogens (AT <sub>c</sub> )	70 yrs	$C_{air-c} = \frac{(TR)(AT_c)(365 \text{ day / year})}{(URF)(EF)(ED)(FT)}$	
Inhalation unit risk factor (URF)	chemical-specific (µg/m <sup>3</sup> ) <sup>-1</sup>		
Exposure Frequency (EF)	15 days/yr		
Exposure Duration (ED)	1 yr		
Fraction of time breathing aboveground contaminated air during a 24 hour day (FT) (assumed 1/2 of work day in trench: 4 hr/24 hr)	0.2 unitless		
Target hazard quotient (THQ)	1 unitless	Noncarcinogenic:	
Inhalation reference concentration (RfC)	chemical-specific µg/m <sup>3</sup>		
Averaging Time, Noncarcinogens (AT <sub>nc</sub> )	1 yr	$C_{air-nc} = \frac{(THQ)(RfC)(AT_{nc})(365 \text{ day / year})}{(EF)(ED)(FT)}$	

Contaminant	CAS Number <sup>b/</sup>	Chemical Type <sup>c/</sup>	URF (µg/m <sup>3</sup> ) <sup>-1</sup>	RfC (µg/m <sup>3</sup> )	C <sub>air-c</sub> (µg/m <sup>3</sup> )	C <sub>air-nc</sub> (µg/m <sup>3</sup> )	C <sub>air</sub> (µg/m <sup>3</sup> )
<b>Polynuclear Aromatic Hydrocarbons</b>							
Benzo(b)fluoranthene	205-99-2	0	8.80E-05	- <sup>d/</sup>	1.16E+02	--	1.16E+02
Benzo(k)fluoranthene	207-08-9	0	8.80E-06	--	1.16E+03	--	1.16E+03

<sup>a/</sup> µg/m<sup>3</sup> = microgram per cubic meter

<sup>b/</sup> CAS = Chemical Abstracts Service number.

<sup>c/</sup> "0" = organic; "\*" = inorganic

<sup>d/</sup> -- = toxicity data not available.

**CALCULATION OF SITE-SPECIFIC TARGET LEVELS - GROUNDWATER<sup>u</sup>**  
**INDUSTRIAL LAND USE ASSUMPTIONS - CONSTRUCTION SCENARIO**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

**Exposure Assumptions**

Receptor	Construction Worker	
Site-specific target level for combined exposure routes (SSTL)	chem.-specific	µg/L <sup>u</sup>
Site-specific target level based on incidental ingestion of groundwater (SSTL <sub>ing</sub> )	chem.-specific	µg/L
Site-specific target level based on dermal contact with groundwater (SSTL <sub>derm</sub> )	chem.-specific	µg/L
Site-specific target level based on aboveground inhalation of contaminants volatilized from groundwater (SSTL <sub>inhal-above</sub> )	chem.-specific	µg/L
Site-specific target level based on inhalation of contaminants volatilized from groundwater into the trench (SSTL <sub>inhal-trench</sub> )	chem.-specific	µg/L

**SSTL Equation (combined exposure routes)**

$$SSTL = \frac{1}{\frac{1}{SSTL_{ing}} + \frac{1}{SSTL_{derm}} + \frac{1}{SSTL_{inhal-above}} + \frac{1}{SSTL_{inhal-trench}}}$$

CAS	RME SCENARIO <sup>u</sup>					CT SCENARIO <sup>u</sup>					
	SSTL <sub>ing</sub> (µg/L)	SSTL <sub>derm</sub> (µg/L)	SSTL <sub>inhal-above</sub> (µg/L)	SSTL <sub>inhal-trench</sub> (µg/L)	SSTL <sub>RME</sub> (µg/L)	SSTL <sub>ing</sub> (µg/L)	SSTL <sub>derm</sub> (µg/L)	SSTL <sub>inhal-above</sub> (µg/L)	SSTL <sub>inhal-trench</sub> (µg/L)	SSTL <sub>CT</sub> (µg/L)	
Contaminant	Number <sup>u</sup>										
Polynuclear Aromatic Hydrocarbons											
Benzo(b)fluoranthene	205-99-2	5.33E+03	4.39E+00	3.06E+06	1.43E+04	4.39E+00	6.53E+04	3.47E+01	9.11E+06	4.38E+04	3.47E+01
Benzo(k)fluoranthene	207-08-9	5.33E+04	4.39E+01	2.13E+09	8.77E+06	4.39E+01	6.53E+05	3.47E+02	6.33E+09	2.69E+07	3.47E+02

<sup>u</sup> SSTL calculations based on combining the following exposure routes: incidental ingestion, dermal contact, inhalation of contaminants volatilized from groundwater into aboveground ambient air, and inhalation of contaminants volatilized from groundwater into ambient air in a trench/excavation pit.

<sup>u</sup> CAS = Chemical Abstracts Service number.

<sup>u</sup> µg/L = micrograms per liter

<sup>u</sup> RME = reasonable maximum exposure

<sup>u</sup> CT = central tendency

Solubility &:

Benzo(b)fluoranthene = 1.5 µg/L

Benzo(k)fluoranthene = 0.8 µg/L

per USEPA, 1996

(Soil Screening Guidance)



# CHEMICAL PROPERTIES FOR CONTAMINANTS

SITE ST-08 (BUILDING 41105)  
POPE AFB, NORTH CAROLINA

Contaminant	CAS Number <sup>a/</sup>	Type <sup>a/</sup>	Chemical Properties <sup>a/</sup>											
			S (mg/L H <sub>2</sub> O)	Ref	MW (g/mol)	Log K <sub>ow</sub> (unitless)	H (unitless)	Ref	VF (m <sup>3</sup> /kg)	D <sup>air</sup> (cm <sup>2</sup> /sec)	Ref	D <sup>water</sup> (cm <sup>2</sup> /sec)	Ref	
Polynuclear Aromatic Hydrocarbons														
Benzo(b)fluoranthene	205-99-2	o	1.50E-03	USEPA, 1996	252.32	6.20E+00	USEPA, 1996	4.55E-03	USEPA, 1996	4.67E+06	2.26E-02	USEPA, 1996	5.56E-06	USEPA, 1996
Benzo(k)fluoranthene	207-08-9	o	8.00E-04	USEPA, 1996	252.32	6.20E+00	USEPA, 1996	3.40E-05	USEPA, 1996	3.93E+07	2.26E-02	USEPA, 1996	5.56E-06	USEPA, 1996

<sup>a/</sup> Chemical Properties are defined as follows: S = solubility at 25 ° C, MW = molecular weight, K<sub>ow</sub> = octanol/water partition coefficient, H = Henry's law constant, VF = volatilization factor,

D<sub>air</sub> = diffusion coefficient in air, D<sub>water</sub> = diffusion coefficient in water, t\* = time it takes to reach steady state, K<sub>p</sub> = Permeability coefficient from water, t<sub>lag</sub> = lag time per event,

SF<sub>g</sub> = dermal slope factor (i.e., oral slope factor adjusted for gastrointestinal absorption), RFD<sub>ad</sub> = oral reference dose (i.e., oral reference dose adjusted for gastrointestinal absorption),

B = Relative contribution of permeability coefficients, OAF = oral absorption factor, SF<sub>ad</sub> = oral slope factor, gastrointestinal absorption, URF = inhalation unit risk factor, RfC = inhalation reference concentration.

<sup>a/</sup> CAS = Chemical Abstracts Service number.

<sup>a/</sup> "o" indicates an organic compound, "i" indicates an inorganic compound

<sup>a/</sup> hr = hour

<sup>a/</sup> Ref = References as defined below.

<sup>a/</sup> cm/hr = centimeters per hour

<sup>a/</sup> hr/event = hours per event

<sup>a/</sup> mg/kg-day = milligrams per kilogram-day

<sup>a/</sup> µg/m<sup>3</sup> = micrograms per cubic meter

<sup>a/</sup> -- = toxicity data were not available.

## References:

C = Calculated per USEPA (1992)

E = USEPA National Center for Environmental Assessment per USEPA Region 3 (1998).

K = Kasting and Robinson (1993).

**CHEMICAL PROPERTIES FOR CONTAMINANTS (cont'd)**  
**SITE ST-08 (BUILDING 41105)**  
**POPE AFB, NORTH CAROLINA**

Chemical Properties <sup>u</sup>																	
Ref	K <sub>p</sub>	t <sub>event</sub>	B	Ref	DAF	Ref	OAF	Ref	Sf <sub>ant</sub>	SF <sub>d</sub>	RfD <sub>ant</sub>	RfD <sub>d</sub>	URF	RfC			
( <sup>u</sup> hr)	( <sup>u</sup> cm/hr)	( <sup>u</sup> hr/event)	<sup>u</sup> Ref (unitless)	<sup>u</sup> Ref					(mg/kg-day) <sup>-1,u</sup>	(mg/kg-day) <sup>-1</sup>	(mg/kg-day)	(mg/kg-day)	( <sup>u</sup> μg/m <sup>3</sup> )	( <sup>u</sup> μg/m <sup>3</sup> )			
1.43E+01	C	1.95E-01	K	3.03E+00	C	1.58E+02	C	0.13	Wester, 1990	0.58	Chang, 1943	7.30E-01	E	1.26E+00	E	--	--
1.43E+01	C	1.95E-01	K	3.03E+00	C	1.58E+02	C	0.13	Wester, 1990	0.58	Chang, 1943	7.30E-02	E	1.26E-01	E	8.80E-06	E

## **RISK CLASSIFICATIONS**

#### A. Soil Contamination Report [2L .0115(c)(3)]

Within 90 days of discovery of a discharge or release, the responsible party must submit a Soil Contamination Report demonstrating the soil remaining in the sidewalls and at the base of the excavation are in the unsaturated zone and do not exceed either the soil-to-groundwater or the residential maximum soil contaminant concentrations, whichever are lower. (See Section 7.3) The sidewalls and base of the excavation must be within the unsaturated zone to meet this criteria. If this can be demonstrated to the satisfaction of the Department, then the release will be classified as low risk and the responsible party may request that the Department issue a notice of no further action under 2L .0115(h). Whenever possible, the Soil Contamination Report should be incorporated into the UST Closure Report to expedite risk classification and site closure.

*NOTE: The intent of the Soil Contamination Report is to allow sites with very minor soil contamination (no more than five feet around the sides and bottom of the UST) in the unsaturated zone that does not come in contact with groundwater and that is excavated during UST closure activities, to be closed early in the regulatory process without further site assessment. A Soil Contamination Report is not appropriate for sites where contamination is situated directly on top of the bedrock surface. A Limited Site Assessment Report should be submitted instead.*

#### B. Limited Site Assessment Report [2L .0115(c)(4)]

If a responsible party cannot demonstrate that soil contamination has been cleaned up as required under 2L .0115(c)(3), a LSA report must be submitted to the Department within 120 days of the discovery of the discharge or release. This report must contain all of the information needed by the Department to classify the level of risk posed to human health and the environment by the discharge or release. The report should also contain a discussion of site-specific conditions or possible actions that could result in lowering the risk classification that will be assigned to the release.

Based on a review of the LSA report, the Department will classify the risk of the discharge or release as high, intermediate or low risk. The Department will then notify the responsible party of the risk classification.

### 4.3 Risk Classifications [2L .0115(d)]

Listed below are the criteria that will be used to determine the risk posed by a discharge or release. If the criteria for more than one risk category apply, the discharge or release will be classified as the highest applicable risk classification. Risk classification of a discharge or release is an on-going process. As new site information concerning the potential exposure of receptors to contamination or changed site conditions becomes available, the Department may reclassify the risk posed by the discharge or release.

#### A. High Risk

A high risk classification means that any of the following apply:

- 1) an existing water supply well, including one used for non-drinking purposes, has been contaminated by the discharge or release;
- 2) a water supply well used for drinking water is located within 1000 feet of the source area of a confirmed discharge or release;
- 3) a water supply well not used for drinking water is located within 250 feet of the source area of a confirmed discharge or release;
- 4) the groundwater within 500 feet of the source area of a confirmed discharge or release has the potential for future use in that there is no source of water supply other than the groundwater;
- 5) the vapors from the discharge or release pose a serious threat of explosion due to accumulation of the vapors in a confined space; or
- 6) the discharge or release poses an imminent danger to public health, public safety, or the environment.

#### B. Intermediate Risk

An intermediate risk classification means that any of the following apply:

- 1) surface water is located within 500 feet of the source area of a confirmed discharge or release and the maximum groundwater contaminant concentration exceeds the applicable surface water quality standard and criteria found in 15A NCAC 2B .0200 by a factor of 10;
- 2) in the Coastal Plain Physiographic Province as designated on a map entitled "Geology of North Carolina" published by the Department in 1985, the source area of a confirmed discharge or release is located in an area in which there is recharge to an unconfined or semi-confined deeper aquifer which the Department determines is being used or may be used as a source of drinking water;
- 3) the source area of a confirmed discharge or release is located within a designated wellhead protection area, as defined in 42 USC 300h-7(e);
- 4) the levels of groundwater contamination for any contaminant except ethylene dibromide, benzene and alkane and aromatic carbon fraction classes exceed 50 percent of the solubility of the contaminant at 25 degrees Celsius or 1000 times the groundwater quality standard or interim standard established in 15A NCAC 2L .0202, whichever is lower (*these levels have been termed as "gross contamination levels"*); or
- 5) the levels of groundwater contamination for ethylene dibromide or benzene exceed 1000 times the federal drinking water standard set out in 40 CFR 141 (*these levels have also been termed as "gross contamination levels"*).

NOTE: *The presence of free product on a site will classify the site, at a minimum, as intermediate risk based on gross contamination levels.*

It should be noted that although interim groundwater quality standards have been established for the alkane and aromatic carbon fraction classes, 15A NCAC 2L .0115 excludes these constituents from the gross contamination levels (GCLs) set under the intermediate risk criteria and cleanup goals. Given that the interim standards have only recently been established and the uncertainty as to the concentrations that may be present in groundwater at release sites, no levels for the alkane and aromatic carbon fraction classes have been established at this time. Therefore, these constituents will not be considered in a determination of the risk classification.

#### C. Low Risk

A low risk classification means that the risk posed by a discharge or release does not meet any of the high or intermediate risk criteria or that based on site-specific information received by the Department, the discharge or release is shown to pose no significant risk.

### 4.4 Land Use Classification

At the time the Department determines the risk posed by a discharge or release, the Department will also determine the land use classification (residential or industrial/commercial) of a site. A site will be presumed residential unless sufficient site-specific information is submitted demonstrating that exposure to the soil contamination is limited in time due to the use of the site and does not involve exposure to children. Information submitted in the LSA Report will be used for the initial land use classification determination. If after the submittal of the LSA Report additional information becomes available that may change the land use classification, it must be submitted to the Regional Office.

### 4.5 Groundwater Assessment and Cleanup

(Discharges or releases reported on or after January 2, 1998)

A flowchart summarizing the regulatory requirements for discharges or releases reported on or after January 2, 1998 is provided as Figure 2.

*NOTE: For purposes of these guidelines, Corrective Action Plan (CAP) means a proposal to remediate groundwater and/or soil through active treatment (e.g., pump and treat, air sparging), remediation by natural attenuation (groundwater monitoring plan as designated in 15A NCAC 2L .0115), or a combination of these alternatives.*

#### A. High Risk Releases [2L .0115(f)]

For a high risk discharge or release, the responsible party must perform a comprehensive site assessment (CSA) and submit a report documenting the results. If the Department cannot reclassify the discharge or release as low risk following receipt of the CSA report, a Corrective Action Plan (CAP) must be submitted. *Soil cleanup goals must be considered before a high risk discharge or release can be reclassified as intermediate or low risk. If soil contamination warrants cleanup to high or intermediate risk levels, the discharge or release cannot be reclassified as low risk until soil remediation is complete.*

A CAP must propose appropriate remediation strategies to restore groundwater quality to the level of the standards established in 15A NCAC 2L .0202. In any CAP, natural attenuation (see Appendix A2.7) must be considered as a remedial option and used to the maximum extent

**TABLE 6.3 (Concluded)**  
**COUPLED OXIDATION REACTIONS**  
 Risk-Based Approach to Remediation  
 Building 4522  
 Seymour Johnson AFB, North Carolina

Coupled Naphthalene Oxidation Reactions	$\Delta G^\circ_r$ (kcal/mole naphthalene)	$\Delta G^\circ_r$ (kJ/mole naphthalene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$12O_2 + C_{10}H_8 \Rightarrow 10CO_2 + 4H_2O$ <i>Naphthalene oxidation / aerobic respiration</i>	-1217.40	-5094	3.00:1
$9.6NO_3^- + 9.6H^+ + C_{10}H_8 \Rightarrow 10CO_2 + 8.8H_2O + 4.8N_2$ <i>Naphthalene oxidation / denitrification</i>	-1234.04	-5163	4.65:1
$24MnO_2 + 48H^+ + C_{10}H_8 \Rightarrow 10CO_2 + 24Mn^{2+} + 28H_2O$ <i>Naphthalene oxidation / manganese reduction</i>	-1217.57	-5094	16.31:1
$48Fe(OH)_3 \cdot a + 96H^+ + C_{10}H_8 \Rightarrow 10CO_2 + 48Fe^{2+} + 124H_2O$ <i>Naphthalene oxidation / iron reduction</i>	-932.64	-3902	40.13:1
$6SO_4^{2-} + 12H^+ + C_{10}H_8 \Rightarrow 10CO_2 + 6H_2S^0 + 4H_2O$ <i>Error! Switch argument not specified. Naphthalene oxidation / sulfate reduction</i>	-196.98	-824.2	4.50:1
$8H_2O + C_{10}H_8 \Rightarrow 4CO_2 + 6CH_4$ <i>Naphthalene oxidation / methanogenesis</i>	-44.49	-186.1	0.75:1

<sup>a</sup> Mass of ferrous iron produced during microbial respiration.

<sup>b</sup> Mass of methane produced during microbial respiration.

**TABLE 6.3 (Continued)**  
**COUPLED OXIDATION REACTIONS**  
 Risk-Based Approach to Remediation  
 Building 4522  
 Seymour Johnson AFB, North Carolina

Coupled Ethylbenzene Oxidation Reactions	$\Delta G^\circ$ , (kcal/mole Ethyl- benzene)	$\Delta G^\circ$ , (kJ/mole Ethyl- benzene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$10.5 O_2 + C_6H_5C_2H_5 \Rightarrow 8 CO_{2g} + 5 H_2O$ <i>Ethylbenzene oxidation / aerobic respiration</i>	-1066.13	-4461	3.17:1
$8.4 NO_3^- + 8.4 H^+ + C_6H_5C_2H_5 \Rightarrow 8 CO_{2g} + 9.2 H_2O + 4.2 N_{2g}$ <i>Ethylbenzene oxidation / denitrification</i>	-1080.76	-4522	4.92:1
$42 H^+ + 21 MnO_2 + C_6H_5C_2H_5 \Rightarrow 8 CO_{2g} + 21 Mn^{2+} + 26 H_2O$ <i>Ethylbenzene oxidation / manganese reduction</i>	-1066.27	-4461	17.24:1
$84 H^+ + 42 Fe(OH)_3 + C_6H_5C_2H_5 \Rightarrow 8 CO_2 + 42 Fe^{2+} + 110 H_2O$ <i>Ethylbenzene oxidation / iron reduction</i>	-778.48	-3257	22:1 <sup>w</sup>
$10.5 H^+ + 5.25 SO_4^{2-} + C_6H_5C_2H_5 \Rightarrow 8 CO_{2g} + 5.25 H_2S^o + 5 H_2O$ <i>Ethylbenzene oxidation / sulfate reduction</i>	-166.75	-697.7	4.75:1
$5.5 H_2O + C_6H_5C_2H_5 \Rightarrow 2.75 CO_{2g} + 5.25 CH_4$ <i>Ethylbenzene oxidation / methanogenesis</i>	-39.83	-166.7	0.79:1 <sup>w</sup>

Coupled m-Xylene Oxidation Reactions	$\Delta G^\circ$ , (kcal/mole m-xylene)	$\Delta G^\circ$ , (kJ/mole m-xylene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$10.5 O_2 + C_6H_4(CH_3)_2 \Rightarrow 8 CO_{2g} + 5 H_2O$ <i>m-Xylene oxidation / aerobic respiration</i>	-1063.25	-4448	3.17:1
$8.4 NO_3^- + 8.4 H^+ + C_6H_4(CH_3)_2 \Rightarrow 8 CO_{2g} + 9.2 H_2O + 4.2 N_{2g}$ <i>m-Xylene oxidation / denitrification</i>	-1077.81	-4509	4.92:1
$42 H^+ + 21 MnO_2 + C_6H_4(CH_3)_2 \Rightarrow 8 CO_{2g} + 21 Mn^{2+} + 26 H_2O$ <i>m-Xylene oxidation / manganese reduction</i>	-1063.39	-4449	17.24:1
$84 H^+ + 42 Fe(OH)_3 + C_6H_4(CH_3)_2 \Rightarrow 8 CO_2 + 42 Fe^{2+} + 110 H_2O$ <i>m-Xylene oxidation / iron reduction</i>	-775.61	-3245	22:1 <sup>w</sup>
$10.5 H^+ + 5.25 SO_4^{2-} + C_6H_4(CH_3)_2 \Rightarrow 8 CO_{2g} + 5.25 H_2S^o + 5 H_2O$ <i>m-Xylene oxidation / sulfate reduction</i>	-163.87	-685.6	4.75:1
$5.5 H_2O + C_6H_4(CH_3)_2 \Rightarrow 2.75 CO_{2g} + 5.25 CH_4$ <i>m-Xylene oxidation / methanogenesis</i>	-36.95	-154.6	0.79:1 <sup>w</sup>



**TABLE 6.3**  
**COUPLED OXIDATION REACTIONS**  
 Risk-Based Approach to Remediation  
 Building 4522  
 Seymour Johnson AFB, North Carolina

Coupled Benzene Oxidation Reactions	$\Delta G^\circ_r$ (kcal/mole Benzene)	$\Delta G^\circ_r$ (kJ/mole Benzene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$7.5 O_2 + C_6H_6 \Rightarrow 6 CO_{2,g} + 3 H_2O$ <i>Benzene oxidation / aerobic respiration</i>	-765.34	-3202	3.07:1
$6 NO_3 + 6 H^+ + C_6H_6 \Rightarrow 6 CO_{2,g} + 6 H_2O + 3 N_{2,g}$ <i>Benzene oxidation / denitrification</i>	-775.75	-3245	4.77:1
$30 H^+ + 15 MnO_2 + C_6H_6 \Rightarrow 6 CO_{2,g} + 15 Mn^{2+} + 18 H_2O$ <i>Benzene oxidation / manganese reduction</i>	-765.45	-3202	10.56:1
$60 H^+ + 30 Fe(OH)_{3,s} + C_6H_6 \Rightarrow 6 CO_2 + 30 Fe^{2+} + 78 H_2O$ <i>Benzene oxidation / iron reduction</i>	-560.10	-2343	21.5:1 <sup>v</sup>
$75 H^+ + 3.75 SO_4^{2-} + C_6H_6 \Rightarrow 6 CO_{2,g} + 3.75 H_2S^o + 3 H_2O$ <i>Benzene oxidation / sulfate reduction</i>	-122.93	-514.3	4.61:1
$4.5 H_2O + C_6H_6 \Rightarrow 2.25 CO_{2,g} + 3.75 CH_4$ <i>Benzene oxidation / methanogenesis</i>	-32.40	-135.6	0.77:1 <sup>w</sup>

Coupled Toluene Oxidation Reactions	$\Delta G^\circ_r$ (kcal/mole Toluene)	$\Delta G^\circ_r$ (kJ/mole Toluene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$9 O_2 + C_6H_5CH_3 \Rightarrow 7 CO_{2,g} + 4 H_2O$ <i>Toluene oxidation / aerobic respiration</i>	-913.76	-3823	3.13:1
$7.2 NO_3 + 7.2 H^+ + C_6H_5CH_3 \Rightarrow 7 CO_{2,g} + 7.6 H_2O + 3.6 N_{2,g}$ <i>Toluene oxidation / denitrification</i>	-926.31	-3875	4.85:1
$36 H^+ + 18 MnO_2 + C_6H_5CH_3 \Rightarrow 7 CO_{2,g} + 18 Mn^{2+} + 22 H_2O$ <i>Toluene oxidation / manganese reduction</i>	-913.89	-3824	10.74:1
$72 H^+ + 36 Fe(OH)_{3,s} + C_6H_5CH_3 \Rightarrow 7 CO_2 + 36 Fe^{2+} + 94 H_2O$ <i>Toluene oxidation / iron reduction</i>	-667.21	-2792	21.86:1 <sup>v</sup>
$9 H^+ + 4.5 SO_4^{2-} + C_6H_5CH_3 \Rightarrow 7 CO_{2,g} + 4.5 H_2S^o + 4 H_2O$ <i>Toluene oxidation / sulfate reduction</i>	-142.86	-597.7	4.7:1
$5 H_2O + C_6H_5CH_3 \Rightarrow 2.5 CO_{2,g} + 4.5 CH_4$ <i>Toluene oxidation / methanogenesis</i>	-34.08	-142.6	0.78:1 <sup>w</sup>

Coupled Benzo(k)fluoranthene Oxidation Reactions	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$18.4\text{NO}_3^- + 18.4\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 15.2\text{H}_2\text{O} + 9.2\text{N}_2$ Benzo(k)fluoranthene oxidation/denitrification	4.53:1
$46\text{MnO}_2 + 92\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 46\text{Mn}^{2+} + 52\text{H}_2\text{O}$ Benzo(k)fluoranthene oxidation/manganese reduction	15.88:1
$92\text{Fe}(\text{OH})_3 + 184\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 92\text{Fe}^{2+} + 236\text{H}_2\text{O}$ Benzo(k)fluoranthene oxidation/iron reduction	39.06:1
$11.5\text{SO}_4^{2-} + 23\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 11.5\text{H}_2\text{S} + 6\text{H}_2\text{O}$ Benzo(k)fluoranthene oxidation/sulfate reduction	4.38:1
$17\text{H}_2\text{O} + \text{C}_{20}\text{H}_{12} \Rightarrow 8.5\text{CO}_2 + 11.5\text{CH}_4$ Benzo(k)fluoranthene oxidation/methanogenesis	0.73:1

Coupled Benzo(b)fluoranthene Oxidation Reactions	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$18.4\text{NO}_3^- + 18.4\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 15.2\text{H}_2\text{O} + 9.2\text{N}_2$ Benzo(b)fluoranthene oxidation/denitrification	4.53:1
$46\text{MnO}_2 + 92\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 46\text{Mn}^{2+} + 52\text{H}_2\text{O}$ Benzo(b)fluoranthene oxidation/manganese reduction	15.88:1
$92\text{Fe}(\text{OH})_3 + 184\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 92\text{Fe}^{2+} + 236\text{H}_2\text{O}$ Benzo(b)fluoranthene oxidation/iron reduction	39.06:1
$11.5\text{SO}_4^{2-} + 23\text{H}^+ + \text{C}_{20}\text{H}_{12} \Rightarrow 20\text{CO}_2 + 11.5\text{H}_2\text{S} + 6\text{H}_2\text{O}$ Benzo(b)fluoranthene oxidation/sulfate reduction	4.38:1
$17\text{H}_2\text{O} + \text{C}_{20}\text{H}_{12} \Rightarrow 8.5\text{CO}_2 + 11.5\text{CH}_4$ Benzo(b)fluoranthene oxidation/methanogenesis	0.73:1

**APPENDIX E**  
**BIOSCREEN MODELING DATA**

## Air Force Center for Environmental Excellence

### Data Input Instructions:

115 1 Enter value directly...or  
2 Calculate by filling in grey  
↑ or

Pone AFB

ST-08

Seepage Velocity*	$V_s$	186.0	(ft/yr)
or			
Hydraulic Conductivity	$K$	1.2E-03	(cm/sec)
Hydraulic Gradient	$i$	0.03	(ft/ft)
Porosity	$n$	0.2	(-)

Modeled Area Length*	500
Modeled Area Width*	200
Simulation Time*	20

Longitudinal Dispersion*	alpha x	(ft)	20.0
Transverse Dispersion*	alpha y	(ft)	2.0
Vertical Dispersion*	alpha z	(ft)	0.0
or	↑	or	
Estimated Plume Length	Lp	(ft)	200

Source Thickness in Sat Zone\*  (ft)

Source Zones:

Width\* (ft) Conc. (mg/l) \*

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2 and 3

Width* (ft)	Conc. (mg/L)*
25	0.05
15	0.55
25	1.297
15	0.55
25	0.05

Retardation Factor*	<i>R</i>	1.4	(-)
or		↑ or	
Soil Bulk Density	<i>ρ<sub>so</sub></i>	1.7	(kg/l)
Partition Coefficient	<i>K<sub>oc</sub></i>	38	(L/kg)
Fraction Organic Carbon	<i>f<sub>oc</sub></i>	57E-5	(-)

Infinite	Infinite	(g)
Inst React	1st Order	
Stable Mass	Infinite	(Kg)
In Source Map	Soil	

1st Order Decay Coeff* or Solute Half-Life	$\lambda$ (mole l-hat (per yr)	or $t_{1/2}$ (year)
--------------------------------------------------	--------------------------------------	------------------------

## 7. FIELD DATA FOR COMPARISON

Concentration (mg/L)  
Dist from Source (ft)

	(mg/L)
Delta Oxygen*	1.0075
Delta Nitrate*	1.225
Observed Ferrous Iron*	2.86
Delta Sulfate*	15.125
Observed Methane*	0.5685

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

**RUN  
CENTERLINE**

## RUN ARRAY

View Output

## Recalculate This Sheet

### Paste Example Dataset

Restore Formulas for Vs,  
Dispersivities, R, lambda, other

**APPENDIX F**  
**DATA QUALITY ASSESSMENT REPORT**

**APPENDIX F**  
**DATA QUALITY ASSESSMENT REPORT**  
**RISK-BASED APPROACH TO REMEDIATION**  
**POPE AIR FORCE BASE**

**F1.0 INTRODUCTION**

An electronic Level III validation of the Pope AFB analytical data was performed by Parsons ES and consisted of electronically examining data deliverables to determine data quality. The Level III validation included application of data qualifiers to the analytical results based on adherence to method protocols and project-specific quality assurance/quality control (QA/QC) limits. Method protocols reviewed included:

- analytical holding times,
- method blanks (MB),
- trip blanks (TB),
- surrogate spikes,
- matrix spikes/matrix spike duplicates (MS/MSDs),
- laboratory control samples (LCSs), and
- database laboratory flag review.

Data qualifiers were applied to analytical results during the data validation process. All data were validated using method applicable guidelines and in accordance with the *National Functional Guidelines for Organic Data Review* (USEPA, 1994a) and the *National Functional Guidelines for Inorganic Data Review* (USEPA, 1994b).

The following definitions provide explanations of the USEPA (1994a and 1994b) qualifiers assigned to analytical results during data validation. The data qualifiers described were applied to both inorganic and organic results.

- U - The analyte was analyzed for and is not present above the reported PQL.
- J - The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are usable for many purposes.
- R - The data are rejected as unusable for all purposes. The analyte was analyzed for, but the presence or absence of the analyte was not verified. Resampling and reanalysis are necessary to confirm the presence or absence of the analyte.
- UJ - The analyte analyzed for was not present above the reported PQL. The associated numerical value may not accurately or precisely represent the concentration necessary to detect the analyte in the sample.
- J1 - The analyte is qualified as an estimated value solely because it is greater than the method detection limit (MDL) and less than the PQL indicating no laboratory quality issues.

**F2.0 DATA QUALITY**

Data quality for samples that exceeded QA/QC criteria is summarized in this section. All frequency requirements for field sample collection of QA/QC samples (MS/MSDs and blanks) were met. The frequency requirements for laboratory specific method criteria QA/QC were met overall. In Attachment 1, Tables 1-1 and 1-2 present the sample analytical methods and the samples that were qualified during the validation process, respectively.

## F2.1 Surrogate Spikes

Table F2.1 lists all results for target analytes that are out of control with respect to surrogate spike criteria with the percentage of out-of-control results calculated against the total number of samples collected. Methods SW8260 and SW8310 displayed surrogate recovery problems. The concentrations of target compounds in the qualified samples were high and required diluting. As a result, the surrogate concentrations were diluted to less than detectable concentrations and surrogate recoveries could not be determined. All results were qualified as estimated.

**Table F2.1**  
**Out-Of-Control Surrogate Spike Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
SW8260	SW5030	SO	1,1,1,2-Tetrachloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,1,1-Trichloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,1,2,2-Tetrachloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,1,2-Trichloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,1-Dichloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,1-Dichloroethene	UJ	1	4	25%
SW8260	SW5030	SO	1,1-Dichloropropene	UJ	1	4	25%
SW8260	SW5030	SO	1,2,3-Trichlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	1,2,3-Trichloropropane	UJ	1	4	25%
SW8260	SW5030	SO	1,2,4-Trichlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	1,2,4-Trimethylbenzene	J	1	4	25%
SW8260	SW5030	SO	1,2-Dibromo-3-chloropropane	UJ	1	4	25%
SW8260	SW5030	SO	1,2-Dibromoethane (EDB)	UJ	1	4	25%
SW8260	SW5030	SO	1,2-Dichlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	1,2-Dichloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,2-Dichloropropane	UJ	1	4	25%
SW8260	SW5030	SO	1,3,5-Trimethylbenzene	J	1	4	25%
SW8260	SW5030	SO	1,3-Dichlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	1,3-Dichloropropane	UJ	1	4	25%
SW8260	SW5030	SO	1,4-Dichlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	1-Chlorohexane	UJ	1	4	25%
SW8260	SW5030	SO	2,2-Dichloropropane	UJ	1	4	25%
SW8260	SW5030	SO	2-Chlorotoluene	UJ	1	4	25%
SW8260	SW5030	SO	4-Chlorotoluene	UJ	1	4	25%
SW8260	SW5030	SO	Benzene	UJ	1	4	25%
SW8260	SW5030	SO	Bromobenzene	UJ	1	4	25%
SW8260	SW5030	SO	Bromochloromethane	UJ	1	4	25%
SW8260	SW5030	SO	Bromodichloromethane	UJ	1	4	25%
SW8260	SW5030	SO	Bromoform	UJ	1	4	25%
SW8260	SW5030	SO	Bromomethane	UJ	1	4	25%
SW8260	SW5030	SO	Carbon tetrachloride	UJ	1	4	25%
SW8260	SW5030	SO	Chlorobenzene	UJ	1	4	25%
SW8260	SW5030	SO	Chlorodibromomethane	UJ	1	4	25%
SW8260	SW5030	SO	Chloroethane	UJ	1	4	25%



**Table F2.1 (Continued)**  
**Out-Of-Control Surrogate Spike Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
SW8260	SW5030	SO	Chloroform	UJ	1	4	25%
SW8260	SW5030	SO	Chloromethane	UJ	1	4	25%
SW8260	SW5030	SO	cis-1,2-Dichloroethene	UJ	1	4	25%
SW8260	SW5030	SO	cis-1,3-Dichloropropene	UJ	1	4	25%
SW8260	SW5030	SO	Dibromomethane	UJ	1	4	25%
SW8260	SW5030	SO	Dichlorodifluoromethane	UJ	1	4	25%
SW8260	SW5030	SO	Ethylbenzene	J	1	4	25%
SW8260	SW5030	SO	Hexachlorobutadiene	UJ	1	4	25%
SW8260	SW5030	SO	Isopropylbenzene	J	1	4	25%
SW8260	SW5030	SO	m-Xylene & p-Xylene	J	1	4	25%
SW8260	SW5030	SO	Methylene chloride	UJ	1	4	25%
SW8260	SW5030	SO	n-Butylbenzene	J	1	4	25%
SW8260	SW5030	SO	n-Propylbenzene	J	1	4	25%
SW8260	SW5030	SO	Naphthalene	J	1	4	25%
SW8260	SW5030	SO	o-Xylene	J	1	4	25%
SW8260	SW5030	SO	p-Isopropyltoluene	UJ	1	4	25%
SW8260	SW5030	SO	sec-Butylbenzene	J	1	4	25%
SW8260	SW5030	SO	Styrene	UJ	1	4	25%
SW8260	SW5030	SO	tert-Butylbenzene	UJ	1	4	25%
SW8260	SW5030	SO	Tetrachloroethene	UJ	1	4	25%
SW8260	SW5030	SO	Toluene	UJ	1	4	25%
SW8260	SW5030	SO	trans-1,2-Dichloroethene	UJ	1	4	25%
SW8260	SW5030	SO	trans-1,3-Dichloropropene	UJ	1	4	25%
SW8260	SW5030	SO	Trichloroethene	UJ	1	4	25%
SW8260	SW5030	SO	Trichlorofluoromethane	UJ	1	4	25%
SW8260	SW5030	SO	Vinyl chloride	UJ	1	4	25%
SW8310	SW3510	WG	Acenaphthene	UJ	2	4	50%
SW8310	SW3510	WG	Acenaphthylene	UJ	2	4	50%
SW8310	SW3510	WG	Anthracene	J	2	4	50%
SW8310	SW3510	WG	Benzo(a)anthracene	UJ	2	4	50%
SW8310	SW3510	WG	Benzo(a)pyrene	J	1	4	25%
SW8310	SW3510	WG	Benzo(a)pyrene	UJ	1	4	25%
SW8310	SW3510	WG	Benzo(b)fluoranthene	J	1	4	25%
SW8310	SW3510	WG	Benzo(b)fluoranthene	UJ	1	4	25%
SW8310	SW3510	WG	Benzo(ghi)perylene	UJ	2	4	50%
SW8310	SW3510	WG	Benzo(k)fluoranthene	J	1	4	25%
SW8310	SW3510	WG	Benzo(k)fluoranthene	UJ	1	4	25%
SW8310	SW3510	WG	Chrysene	UJ	2	4	50%
SW8310	SW3510	WG	Dibenzo(a,h)anthracene	UJ	2	4	50%
SW8310	SW3510	WG	Fluoranthene	J	1	4	25%
SW8310	SW3510	WG	Fluoranthene	UJ	1	4	25%



**Table F2.1 (Continued)**  
**Out-Of-Control Surrogate Spike Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
SW8310	SW3510	WG	Fluorene	UJ	2	4	50%
SW8310	SW3510	WG	Indeno(1,2,3-cd)pyrene	UJ	2	4	50%
SW8310	SW3510	WG	Naphthalene	J	2	4	50%
SW8310	SW3510	WG	Phenanthrene	J	2	4	50%
SW8310	SW3510	WG	Pyrene	U	1	4	25%
SW8310	SW3510	WG	Pyrene	UJ	1	4	25%

**F2.2 Matrix Spikes/Matrix Spike Duplicates**

MS/MSD validation flags were applied only to the parent sample from a non-compliant MS/MSD. Sample results were not qualified on an analytical batch basis. Table F2.2 lists all results for target compounds that are out of control with respect to MS/MSD criteria with the percentage of out-of-control results calculated against the total number of samples collected. For benzidine and acenaphthene the spike recoveries were 0%. Therefore the samples were rejected. 2-Methylnaphthalene was rejected because the MS recovery was 412%.

**Table F2.2**  
**Out-Of-Control MS/MSD Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
E418.1	SW3550	SO	TRPH	UJ	1	1	100%
E602	SW5030	WG	1,4-Dichlorobenzene	J	1	5	20%
E602	SW5030	WG	Ethylbenzene	J	1	5	20%
E602	SW5030	WG	Toluene	J	1	5	20%
E602	SW5030	WG	Xylenes (total)	J	1	5	20%
E625	SW3520	WG	3,3'-Dichlorobenzidine	UJ	1	3	33%
E625	SW3520	WG	Benzidine	R	1	3	33%
SW8260	SW5030	SO	1,1,2-Trichloroethane	UJ	1	4	25%
SW8260	SW5030	SO	1,2,3-Trichloropropane	UJ	1	4	25%
SW8260	SW5030	SO	Bromomethane	UJ	1	4	25%
SW8260	SW5030	SO	Dichlorodifluoromethane	UJ	1	4	25%
SW8260	SW5030	SO	m-Xylene & p-Xylene	J	1	4	25%
SW8260	SW5030	SO	Trichlorofluoromethane	UJ	1	4	25%
SW8270	SW3550	SO	2-Methylnaphthalene	R	1	3	33%
SW8270	SW3550	SO	Fluoranthene	J	1	3	33%
SW8270	SW3550	SO	Fluorene	J	1	3	33%
SW8270	SW3550	SO	Phenanthrene	J	1	3	33%
SW8270	SW3550	SO	Pyrene	J	1	3	33%
SW8310	SW3510	WG	Acenaphthene	R	1	4	25%
SW8310	SW3510	WG	Phenanthrene	J	1	4	25%
SW8310	SW3510	WG	Pyrene	UJ	1	4	25%

### F2.3 Method Blanks

Table F2.3 lists all results for target compounds that are out of control due to method blank contamination with the percentage of out-of-control results calculated against the total number of samples collected.

**Table F2.3**  
**Out-Of-Control Method Blank Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
E602	SW5030	WG	Toluene	U	1	5	20%
E602	SW5030	WG	Xylenes (total)	U	1	5	20%
RSK175	METHOD	WG	Methane	U	1	4	25%
SW8260	SW5030	SO	Methylene chloride	U	1	4	25%

### F2.4 Laboratory Control Samples

Table F2.4 lists all results for target analytes that are out of control with respect to laboratory control sample (LCS) spike criteria with the percentage of out-of-control results calculated against the total number of samples collected. Methods SW8260 and E625 displayed LCS recovery problems. All out-of-control recoveries were low with 3,3'-dichlorobenzidine and benzidine recovered at 0%. A low bias is probable in the associated sample results for these compounds.

**Table F2.4**  
**Out-Of-Control LCS Impact**

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
E625	SW3520	WG	3,3'-Dichlorobenzidine	R	3	3	100%
E625	SW3520	WG	Benzidine	R	3	3	100%
E625	SW3520	WG	Hexachlorocyclopentadiene	R	2	3	67%
E625	SW3520	WG	N-Nitrosodiphenylamine	UJ	1	3	33%
SW8260	SW5030	SO	Bromomethane	UJ	1	4	25%
SW8260	SW5030	SO	Dichlorodifluoromethane	UJ	3	4	75%

### F2.5 Hardcopy Data Review

A review of the hardcopy data for one sample delivery group, revealed no additional analytical problems other than those noted in the preceding paragraphs.

### F3.0 CONCLUSIONS

Samples were collected and analyzed as specified in the methods with exception of those issues discussed in this report. All samples are representative of the site and comparable with previous and future investigations when used in accordance with the validation qualifiers. All sample results qualified as "UJ or J" represent an association to non-compliant QC criteria which has caused the reported concentration to be estimated. Project objectives do not exclude the use of estimated concentrations. Table F3.0 lists the

compounds for which completeness goals are not met. Therefore, all data (except those qualified as "R") are usable for the purposes intended.

**Table F3.0**  
**Compound Completeness**

<b>Anal. Method</b>	<b>Matrix</b>	<b>Analyte</b>	<b>Number of Rejected Samples</b>	<b>Total Number of Samples</b>	<b>Completeness</b>
E625	WG	3,3'-Dichlorobenzidine	3	3	0
E625	WG	Benzidine	3	3	0
E625	WG	Hexachlorocyclopentadiene	2	3	33
SW8270	SO	2-Methylnaphthalene	1	3	67
SW8310	WG	Acenaphthene	1	4	75

#### **F4.0 REFERENCES**

U.S. Environmental Protection Agency (USEPA). 1983. Methods for the Chemical Analysis of Water and Wastes. EPA 600/4-79-020. Cincinnati, OH.

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USEPA. 1987-1996. SW-846, Test Methods for Evaluating Solid Waste, Physical and Chemical Methods, Third Edition. Washington, DC.

USEPA. 1994a. Agency National Functional Guidelines for Organic Data Review. PB 94-963502. Washington, DC.

USEPA. 1994b. Agency National Functional Guidelines for Inorganic Data Review. PB 94-963501. Washington, DC.

**ATTACHMENT 1**

**VALIDATED SAMPLES AND QUALIFIED ANALYTICAL  
RESULTS**

## VALIDATED SAMPLES AND QUALIFIED ANALYTICAL RESULTS

Tables 1-1 and 1-2 list all qualified sample data based on the results of data validation. The following definitions of column headers will aid in the understanding and use of these tables.

<b>LOCID:</b>	Sample location identifier, unique to each sample when used in conjunction of columns SBD and SED.
<b>MX:</b>	Sample matrix identifier. "SO" is soil, "WG" is water.
<b>SA:</b>	Sample analysis identifier. "N" is for primary field samples, "FR" is for field replicate samples. "N1" or "FR1" designates that the results associate to the original sample analysis. "N8" or "FR8" designates that the results associate to a composite of sample analysis results.
<b>SBD:</b>	Sample beginning depth.
<b>SED:</b>	Sample ending depth.
<b>COMPOUND NAME:</b>	This column identifies the target compound name.
<b>VQ:</b>	This column designates if a target compound was detected or not. An "=" denotes a detection above the project PQL. A "ND" denotes a non-detection above the MDL. A "TR" denotes a detection above the MDL but below the project PQL.
<b>PARVAL:</b>	This is the concentration of detection for all detected sample results (TR or =). A zero is a placeholder, which associates to a non-detected compound. The zero does not imply that the compound was not detected at less than zero.
<b>LABDL:</b>	This is the concentration at which the laboratory reports the project reporting limit. The project reporting limit is a PQL in that it is related to a multiplier of the MDL.
<b>ANMCODE:</b>	Analytical method code identifier.
<b>EXMCODE:</b>	Analytical extraction method code identifier.
<b>Q:</b>	This column represents the final validation qualifier applied to the sample result. It is a composite of all the validation qualifiers for that sample result.

The following column headers apply to the method criteria that are included in data validation. All of the columns may not appear in Table 1-2. Only those method criteria that result in qualifying sample results are listed.

HTM	Holding Time
MBM	Method Blank
TBM	Trip Blank
EBM	Equipment Blank
ABM	Ambient Blank
MSRM	MS/MSD (%Recovery/Accuracy)
MSPM	MS/MSD (%RPD/Precision)
LCRM	LCS (%Recovery/Accuracy)
LCPM	LCS (%RPD/Precision)
SURM	Surrogate
TMPM	Temperature
PRSM	Preservation

TABLE 1-1  
ANALYTICAL METHODS BY SAMPLE LOCATION

LOCID	SBD	SED	MATRIX	D2216	E160_3	E418_1	E602	E625	M2720C	RSK175	SW8260	SW8270	SW8310	SW9056	SW9060
MP8-A	0	0	WG				X	X	X				X	X	
MP8-B	0	0	WG				X	X	X				X	X	
MP8-C	0	0	WG				X								
MW8-06	0	0	WG							X				X	
MW8-08	0	0	WG				X	X					X		
MW8-09	0	0	WG							X				X	
MW8-11	0	0	WG				X			X			X	X	
SB1-9	9	9.5	SO	X		X									
SB2-12	12	13	SO		X						X				
SB2R-12	12	13	SO		X							X			
SB3-12	12	13	SO		X						X				
SB3R-12	12	13	SO		X						X	X			
SB4-12	12	13	SO		X						X				
SB4R-12	12	13	SO		X							X			
SB5-12	12	12.5	SO		X										X
SB6-12	12	12.5	SO		X										X
SW1	0	0	WS				X								
SW2	0	0	WS				X								

TABLE 1-2  
QUALIFIED ANALYTICAL RESULTS

LOCID	SBD	SED	MATRIX	SACODE	ANMCODE	EXMCODE	COMPD_NAME	PARVAL	UTMCODE	Final	LCRM	MBM	MSPM	MSRM	SURM
MP8-A	0	0	WG	N1	E625	SW3520	3,3'-Dichlorobenzidine	0	UG/L	R	R				
MP8-A	0	0	WG	N1	E625	SW3520	Benzidine	0	UG/L	R	R				
MP8-A	0	0	WG	N1	E625	SW3520	Hexachlorocyclopentadiene	0	UG/L	R	R				
MP8-A	0	0	WG	N1	SW8310	SW3510	Acenaphthene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Acenaphthylene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Anthracene	3.5	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Benzo(a)anthracene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Benzo(a)pyrene	1.1	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Benzo(b)fluoranthene	1	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Benzo(ghi)perylene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Benzo(k)fluoranthene	0.7	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Chrysene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Dibenzo(a,h)anthracene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Fluoranthene	20	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Fluorene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Indeno(1,2,3-cd)pyrene	0	UG/L	UJ					UJ
MP8-A	0	0	WG	N1	SW8310	SW3510	Naphthalene	180	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Phenanthrene	27	UG/L	J					J
MP8-A	0	0	WG	N1	SW8310	SW3510	Pyrene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	E602	SW5030	1,4-Dichlorobenzene	13	UG/L	J				J	
MP8-B	0	0	WG	N1	E602	SW5030	Ethylbenzene	16	UG/L	J				J	
MP8-B	0	0	WG	N1	E602	SW5030	Toluene	8.7	UG/L	J				J	
MP8-B	0	0	WG	N1	E602	SW5030	Xylenes (total)	61	UG/L	J				I	
MP8-B	0	0	WG	N1	E625	SW3520	3,3'-Dichlorobenzidine	0	UG/L	R	R				
MP8-B	0	0	WG	N1	E625	SW3520	Benzidine	0	UG/L	R	R				
MP8-B	0	0	WG	N1	E625	SW3520	Hexachlorocyclopentadiene	0	UG/L	R	R				

TABLE 1-2 (Continued)  
QUALIFIED ANALYTICAL RESULTS

LOCID	SBD	SED	MATRIX	SACODE	ANMCODE	EXMCODE	COMPD_NAME	PARVAL	UTMCODE	Final	LCRM	MBM	MSPM	MSRM	SURM
MP8-B	0	0	WG	N1	SW8310	SW3510	Acenaphthene	0	UG/L	Q					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Acenaphthylene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Anthracene	1.1	UG/L	J					J
MP8-B	0	0	WG	N1	SW8310	SW3510	Benzo(a)anthracene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Benzo(a)pyrene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Benzo(b)fluoranthene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Benzo(ghi)perylene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Benzo(k)fluoranthene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Chrysene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Dibenzo(a,h)anthracene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Fluoranthene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Fluorene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Indeno(1,2,3-cd)pyrene	0	UG/L	UJ					UJ
MP8-B	0	0	WG	N1	SW8310	SW3510	Naphthalene	120	UG/L	J					J
MP8-B	0	0	WG	N1	SW8310	SW3510	Phenanthrene	9.7	UG/L	J					J
MP8-B	0	0	WG	N1	SW8310	SW3510	Pyrene	0	UG/L	U					U
MP8-C	0	0	WG	N1	E602	SW5030	Xylenes (total)	0.24	UG/L	U		U			
MW8-06	0	0	WG	N1	RSK175	METHOD	Methane	0.13	UG/L	U		U			
MW8-08	0	0	WG	N1	E602	SW5030	Toluene	0.43	UG/L	U		U			
MW8-08	0	0	WG	N1	E625	SW3520	3,3'-Dichlorobenzidine	0	UG/L	R	R			UJ	
MW8-08	0	0	WG	N1	E625	SW3520	Benidine	0	UG/L	R	R			R	
MW8-08	0	0	WG	N1	E625	SW3520	N-Nitrosodiphenylamine	0	UG/L	UJ	UJ				
MW8-08	0	0	WG	N1	SW8310	SW3510	Acenaphthene	0	UG/L	R				R	
MW8-08	0	0	WG	N1	SW8310	SW3510	Phenanthrene	1.5	UG/L	J				J	
MW8-08	0	0	WG	N1	SW8310	SW3510	Pyrene	0	UG/L	UJ				UJ	



TABLE 1-2 (Continued)  
QUALIFIED ANALYTICAL RESULTS

LOCID	SBD	SED	MATRIX	SACODE	ANMCODE	EXMCODE	COMPD_NAME	PARVAL	UTMCODE	Final Q	LCRM	MBM	MSPM	MSRM	SURM
SB1-9	9	9.5	SO	N1	E418.1	SW3550	TRPH	0	MG/KG	UJ				UJ	
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1,1,2-Tetrachloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1,1-Trichloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1,2,2-Tetrachloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1,2-Trichloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1-Dichloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1-Dichloroethene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,1-Dichloropropene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2,3-Trichlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2,3-Trichloropropane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2,4-Trichlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2,4-Trimethylbenzene	47	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2-Dibromo-3-chloropropane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2-Dibromoethane (EDB)	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2-Dichlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2-Dichloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,2-Dichloropropane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,3,5-Trimethylbenzene	25	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	1,3-Dichlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,3-Dichloropropane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1,4-Dichlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	1-Chlorohexane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	2,2-Dichloropropane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	2-Chlorotoluene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	4-Chlorotoluene	0	MG/KG	UJ					UJ

TABLE 1-2 (Continued)  
QUALIFIED ANALYTICAL RESULTS

LOCID	SBD	SED	MATRIX	SACODE	ANMCODE	EXMCODE	COMPD_NAME	PARVAL	UTMCODE	Final	LCRM	MBM	MSPM	MSRM	SURM
SB2-12	12	13	SO	N1	SW8260	SW5030	Benzene	0	MG/KG	Q					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Bromobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Bromochloromethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Bromodichloromethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Bromoform	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Bromomethane	0	MG/KG	UJ	UJ				UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Carbon tetrachloride	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Chlorobenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Chlorodibromomethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Chloroethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Chloroform	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Chloromethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	cis-1,2-Dichloroethene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	cis-1,3-Dichloropropene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Dibromomethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Dichlorodifluoromethane	0	MG/KG	UJ	UJ				UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Ethylbenzene	6	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	Hexachlorobutadiene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Isopropylbenzene	3.5	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	m-Xylene & p-Xylene	42	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	Methylene chloride	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	n-Butylbenzene	7.9	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	n-Propylbenzene	4.4	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	Naphthalene	22	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	o-Xylene	5.6	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	p-Isopropyltoluene	0	MG/KG	UJ					UJ

TABLE 1-2 (Continued)  
QUALIFIED ANALYTICAL RESULTS

LOCID	SBD	SED	MATRIX	SACODE	ANMCODE	EXMCODE	COMPD_NAME	PARVAL	UTMCODE	Final	LCRM	MBM	MSPM	MSRM	SURM
SB2-12	12	13	SO	N1	SW8260	SW5030	Sec-Butylbenzene	3.9	MG/KG	J					J
SB2-12	12	13	SO	N1	SW8260	SW5030	Styrene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Tert-Butylbenzene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Tetrachloroethene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Toluene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Trans-1,2-Dichloroethene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	trans-1,3-Dichloropropene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Trichloroethene	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Trichlorofluoromethane	0	MG/KG	UJ					UJ
SB2-12	12	13	SO	N1	SW8260	SW5030	Vinyl chloride	0	MG/KG	UJ					UJ
SB2R-12	12	13	SO	N1	SW8270	SW3550	2-Methylnaphthalene	1.2	MG/KG	R				R	
SB2R-12	12	13	SO	N1	SW8270	SW3550	Fluoranthene	0.29	MG/KG	J				J	
SB2R-12	12	13	SO	N1	SW8270	SW3550	Fluorene	0.23	MG/KG	J				J	
SB2R-12	12	13	SO	N1	SW8270	SW3550	Phenanthrene	0.63	MG/KG	J				J	
SB2R-12	12	13	SO	N1	SW8270	SW3550	Pyrene	0.28	MG/KG	J			J		
SB3-12	12	13	SO	N1	SW8260	SW5030	Dichlorodifluoromethane	0	MG/KG	UJ	UJ				
SB3R-12	12	13	SO	N1	SW8260	SW5030	m-Xylene & p-Xylene	0.091	MG/KG	J				J	
SB3R-12	12	13	SO	N1	SW8260	SW5030	Methylene chloride	0.0023	MG/KG	U		U			
SB4-12	12	13	SO	N1	SW8260	SW5030	1,1,2-Trichloroethane	0	MG/KG	UJ				UJ	
SB4-12	12	13	SO	N1	SW8260	SW5030	1,2,3-Trichloropropane	0	MG/KG	UJ				UJ	
SB4-12	12	13	SO	N1	SW8260	SW5030	Bromomethane	0	MG/KG	UJ				UJ	
SB4-12	12	13	SO	N1	SW8260	SW5030	Dichlorodifluoromethane	0	MG/KG	UJ	UJ			UJ	
SB4-12	12	13	SO	N1	SW8260	SW5030	Trichlorofluoromethane	0	MG/KG	UJ				UJ	